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(12) **United States Patent**
Hess

(10) **Patent No.: US 9,255,600 B2**
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(54) **RATCHET LOCKING MECHANISM FOR THREADED FASTENER**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

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(65) **Prior Publication Data**

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Related U.S. Application Data

(62) Division of application No. 13/068,171, filed on May 4, 2011, now Pat. No. 8,784,027.

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(51) **Int. Cl.**

F16B 39/32	(2006.01)
F16B 39/12	(2006.01)
F16B 39/24	(2006.01)

(52) **U.S. Cl.**

CPC ***F16B 39/12*** (2013.01); ***F16B 39/24*** (2013.01); ***F16B 39/32*** (2013.01)

(58) **Field of Classification Search**

CPC F16B 39/10; F16B 39/32; F16B 39/12; F16B 39/24

USPC 411/204–205, 326, 327, 329, 330–331, 411/933, 949, 950, 953, 961, 962

See application file for complete search history.

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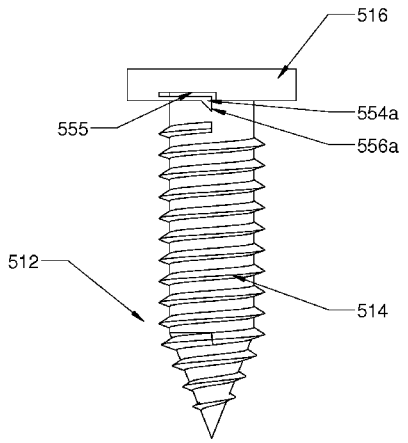
Primary Examiner — Roberta Delisle

(74) *Attorney, Agent, or Firm* — Locke Lord LLP; Scott D. Wofsy

(57) **ABSTRACT**

A fastening device including a fastener having a head portion and an elongated threaded body portion extending axially from the head portion. The threaded body portion includes opposing flat sections. A lock washer has a lower surface with an array of radially extending engagement teeth. The lock washer also defines an axial aperture for receiving the fastener. The axial aperture has two flat inner surfaces for cooperating with the two flat sections of the threaded body portion to prevent relative rotation of the washer and threaded body portion. A threaded lock nut mates with the threaded body portion. The lock nut has an upper surface with at least one cantilevered pawl members for ratcheted engagement with the array of radially extending engagement teeth of the lock washer.

18 Claims, 26 Drawing Sheets



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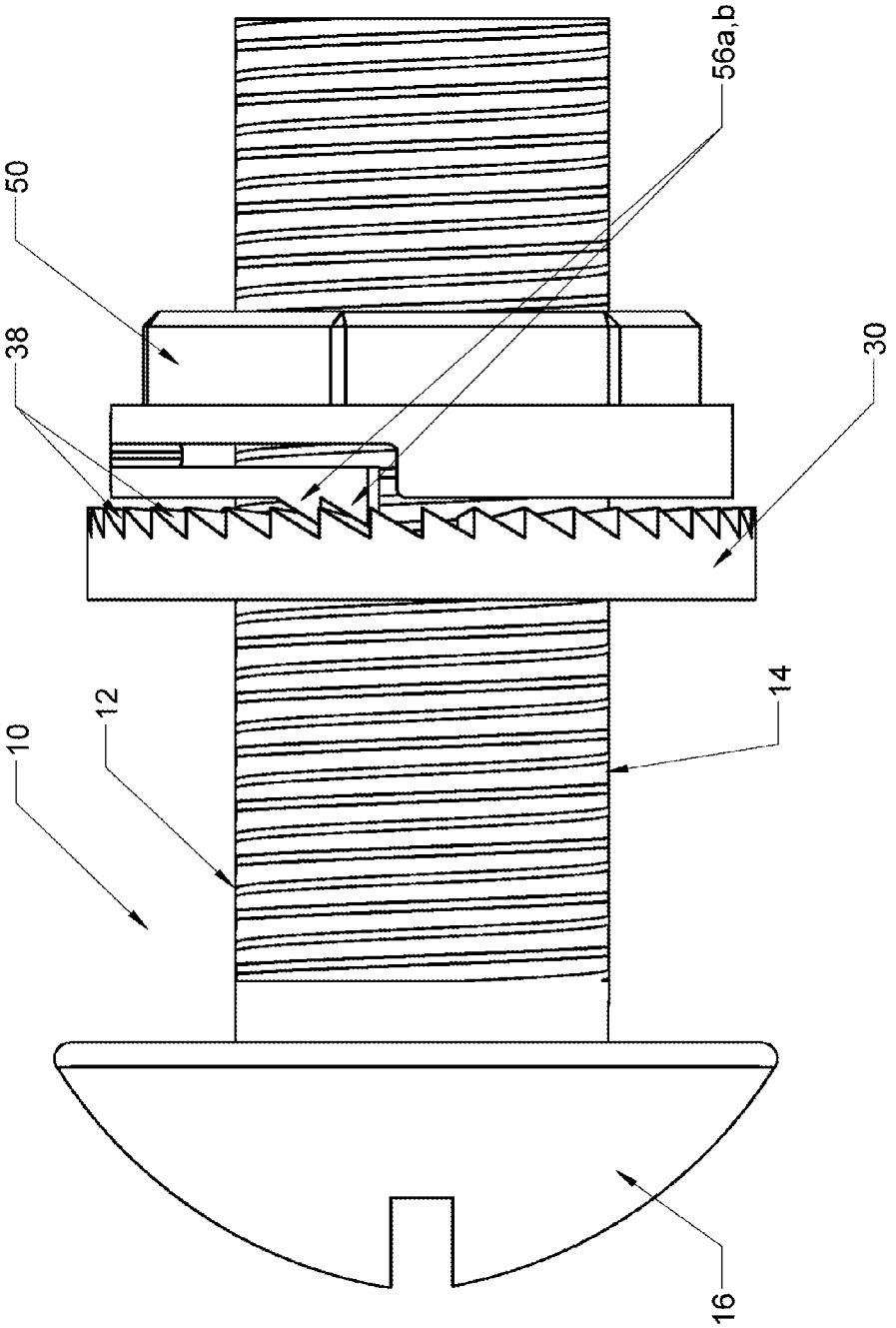

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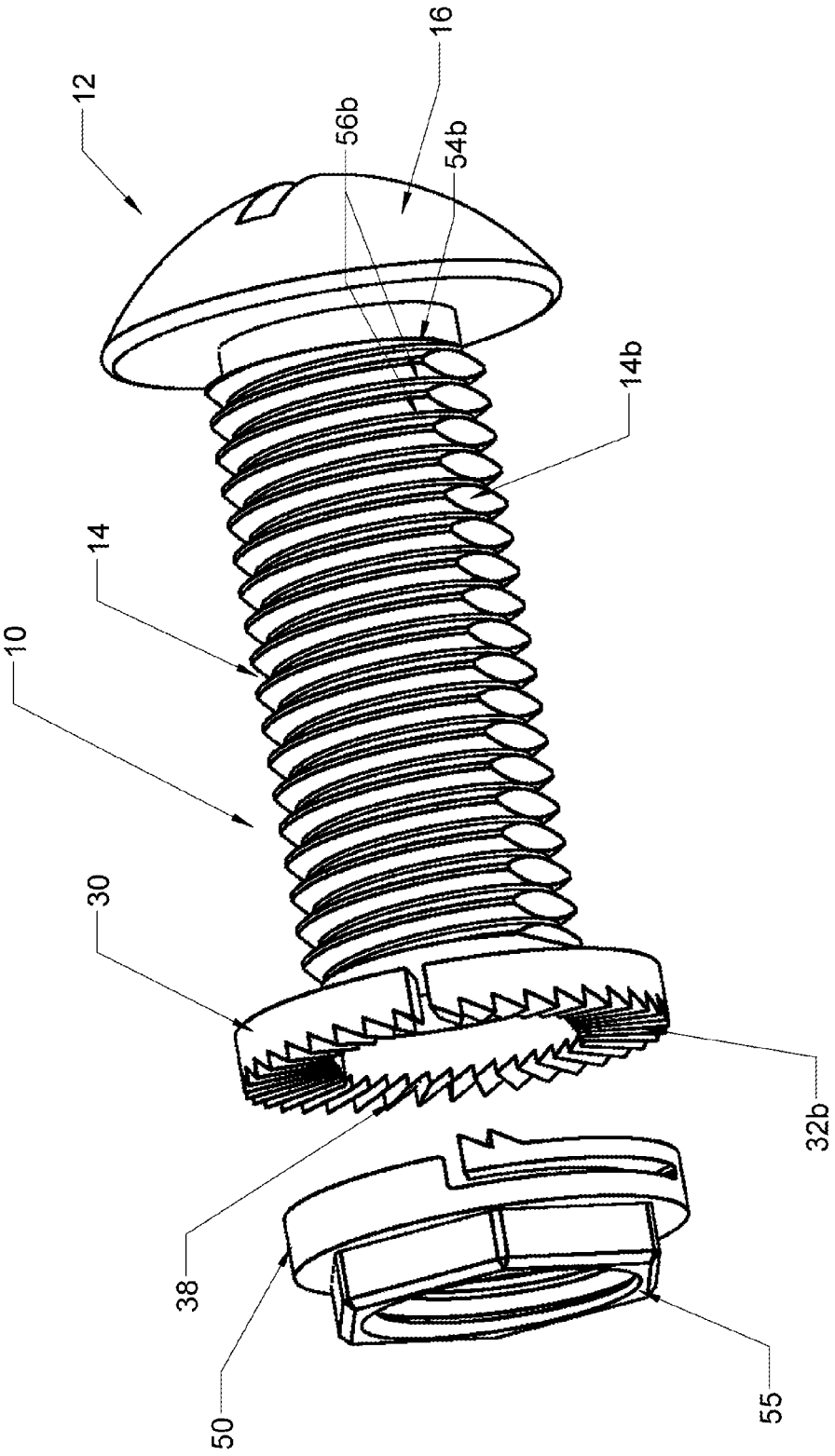

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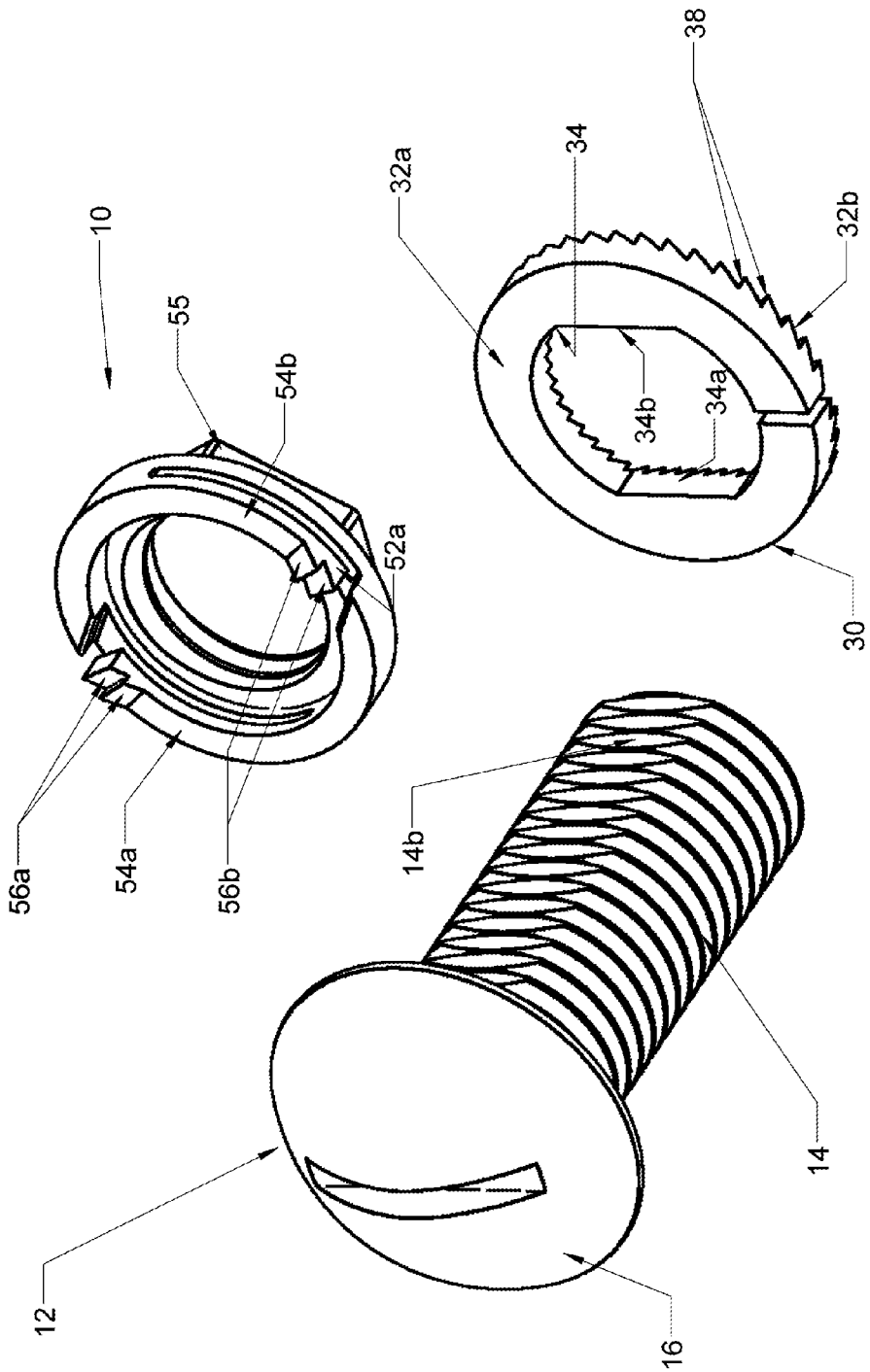

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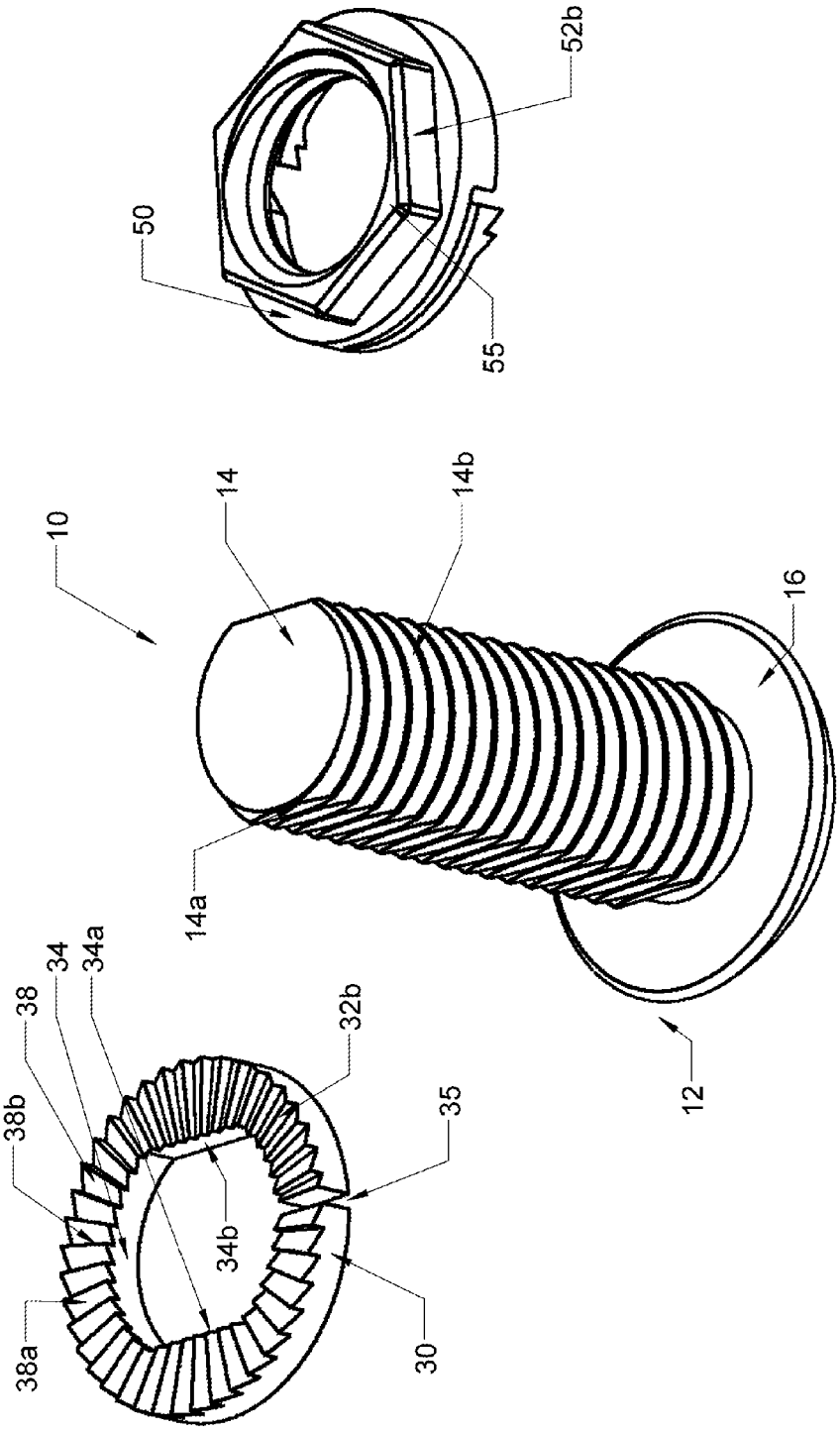

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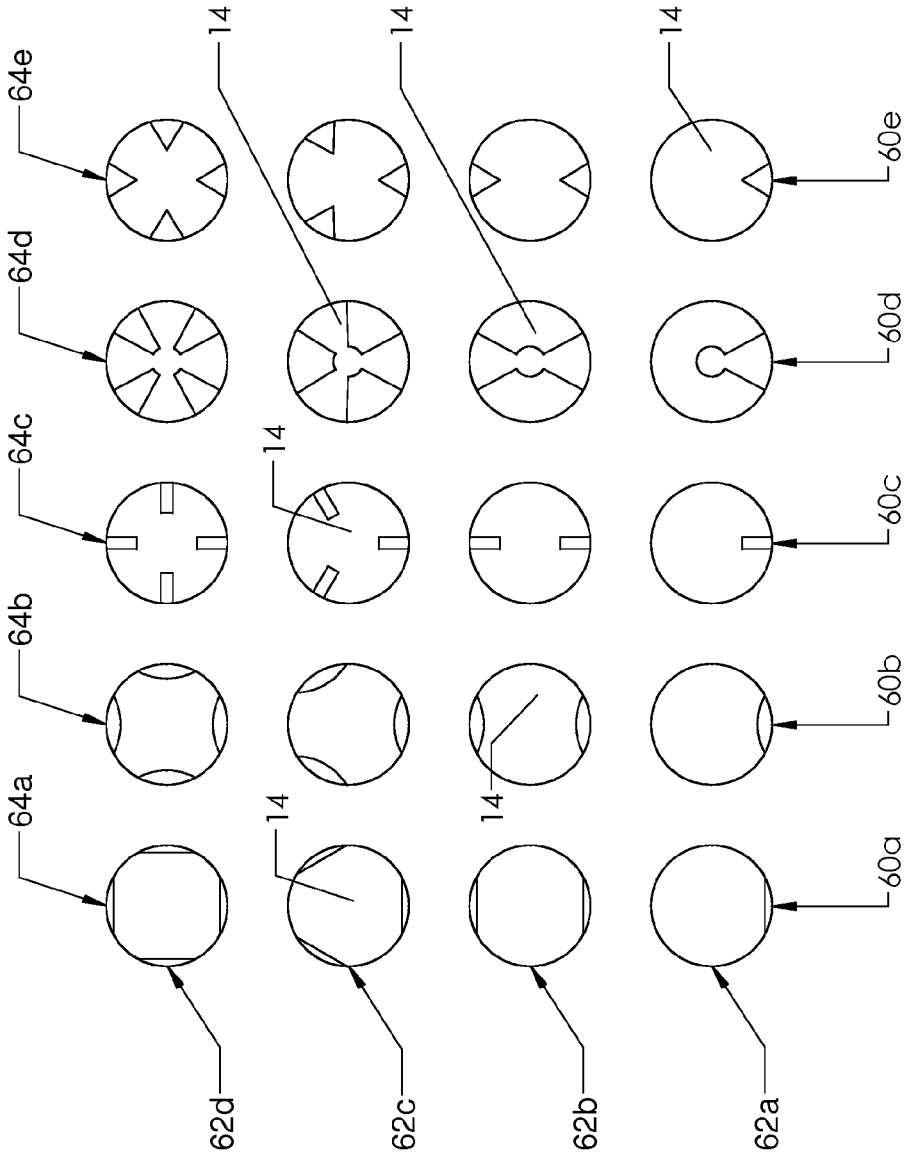

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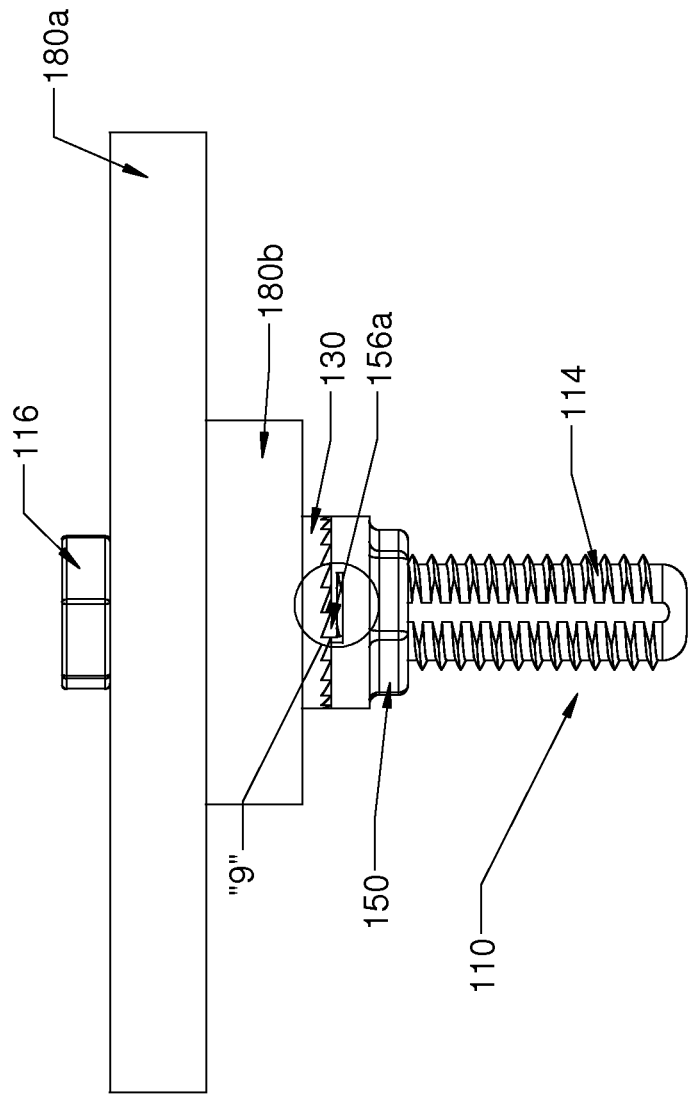

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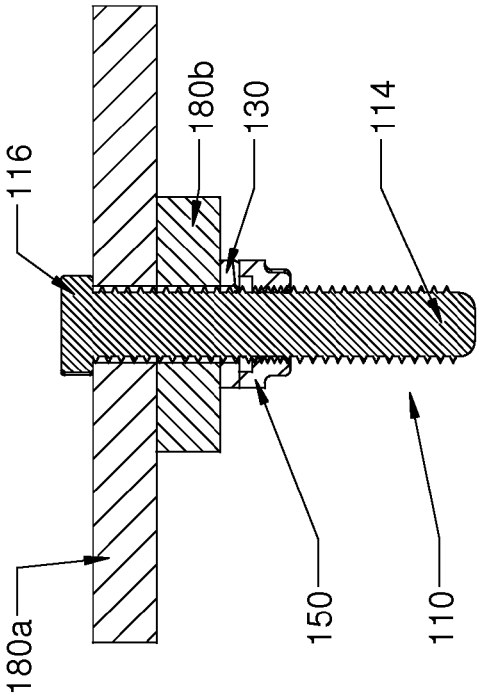

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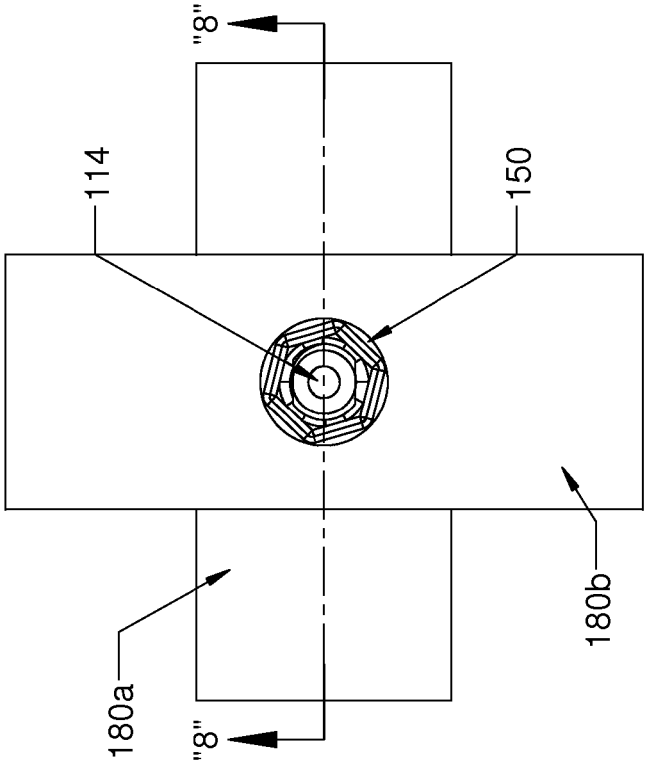

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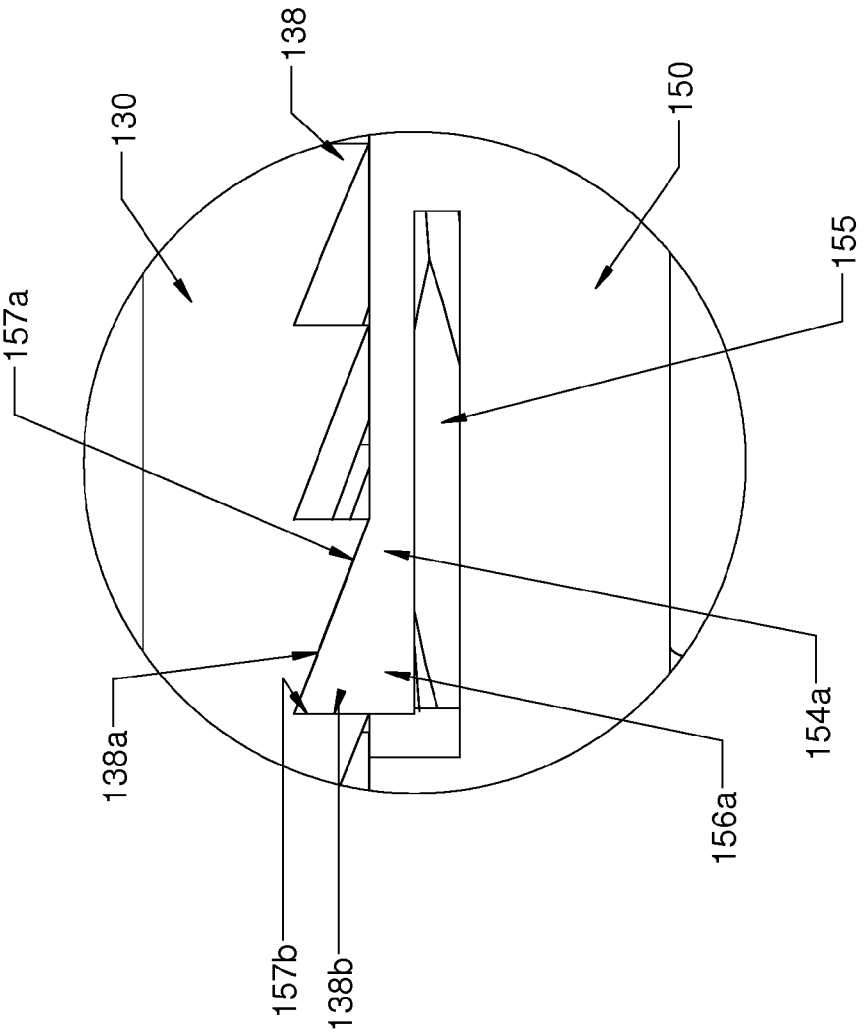

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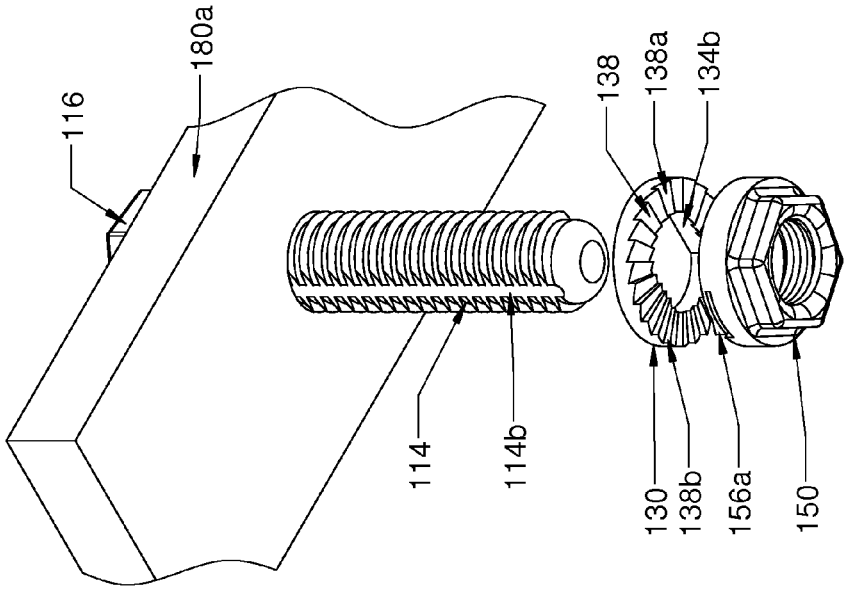
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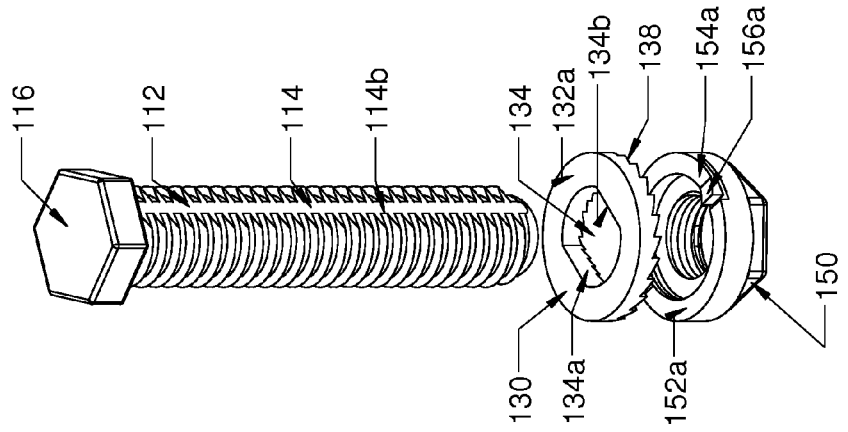
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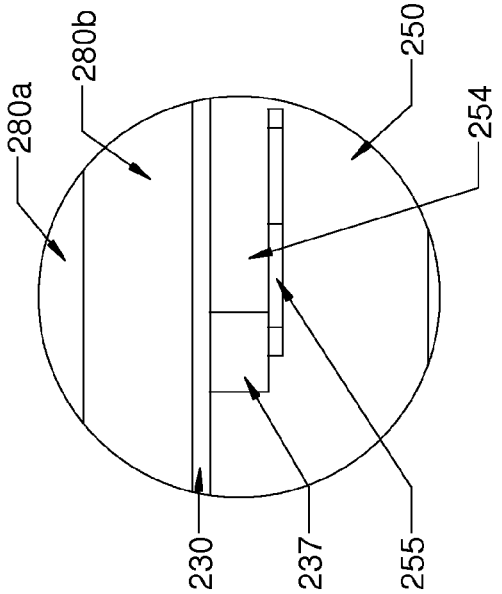
Fig. 10



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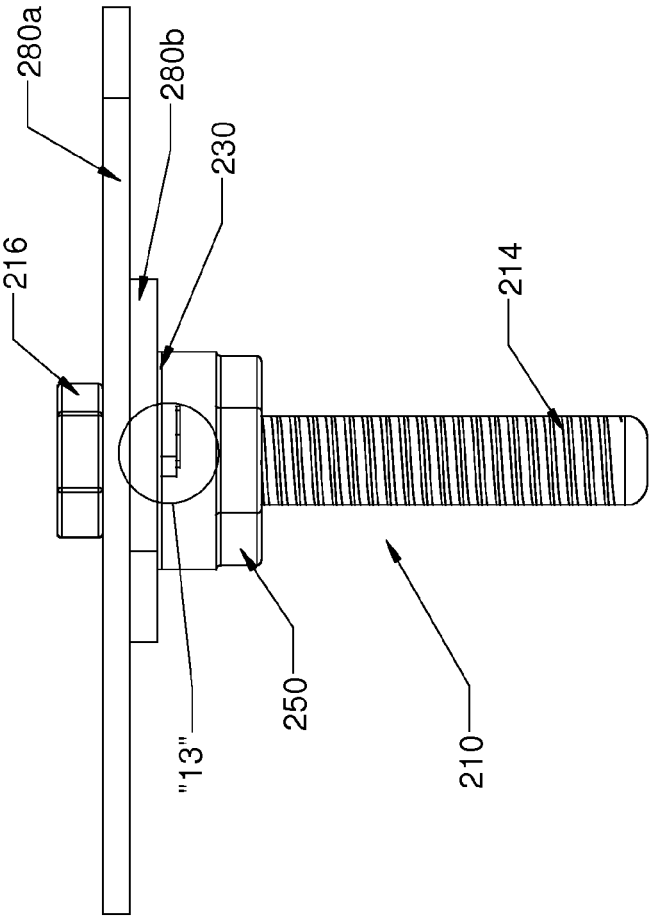

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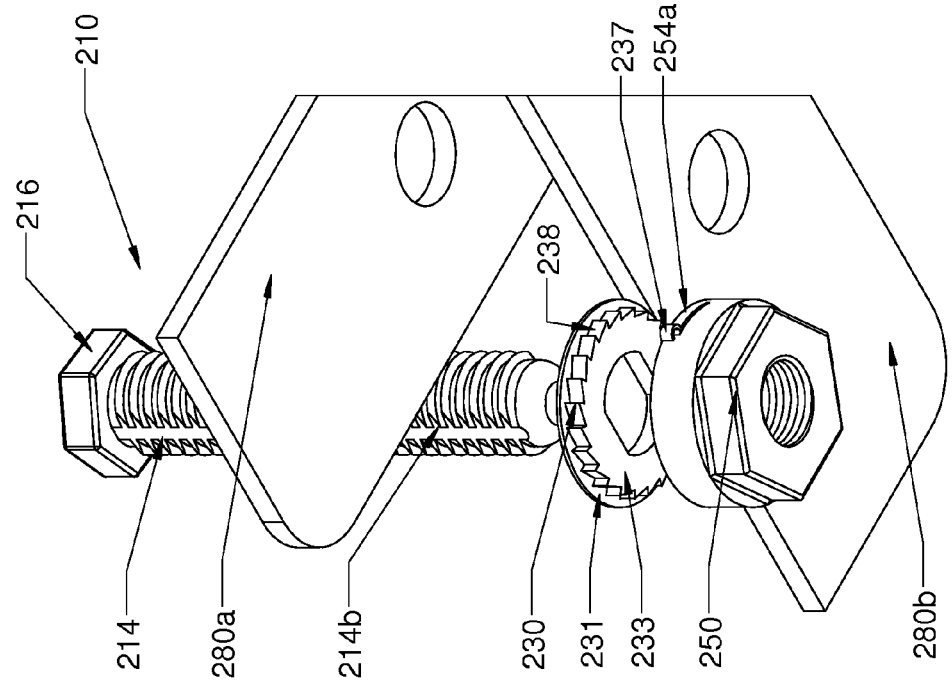
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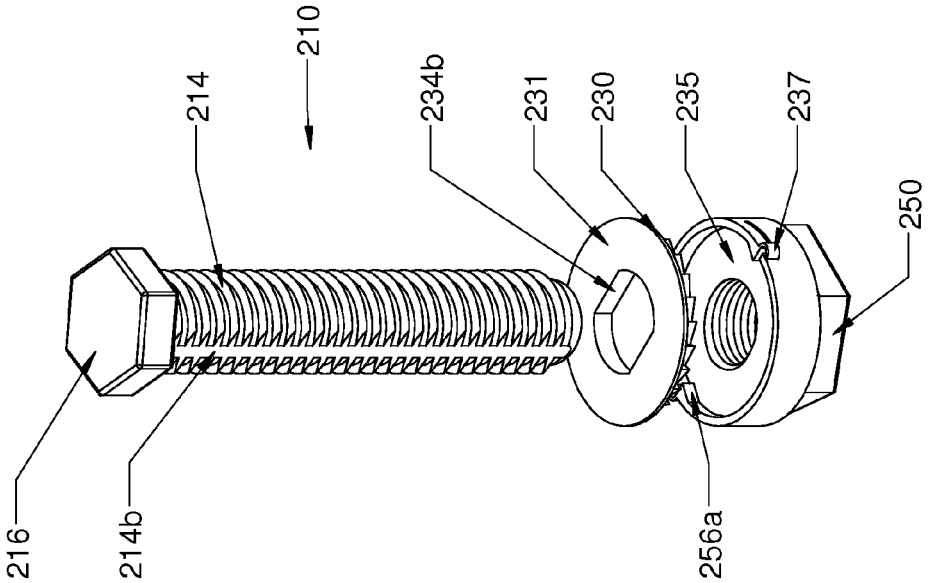
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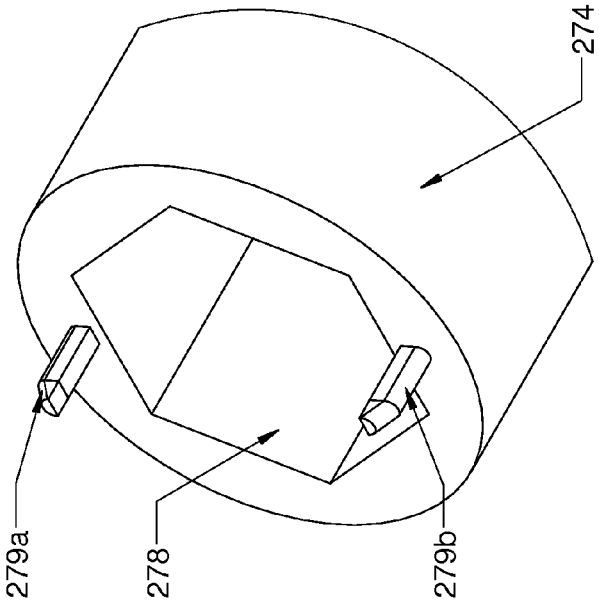

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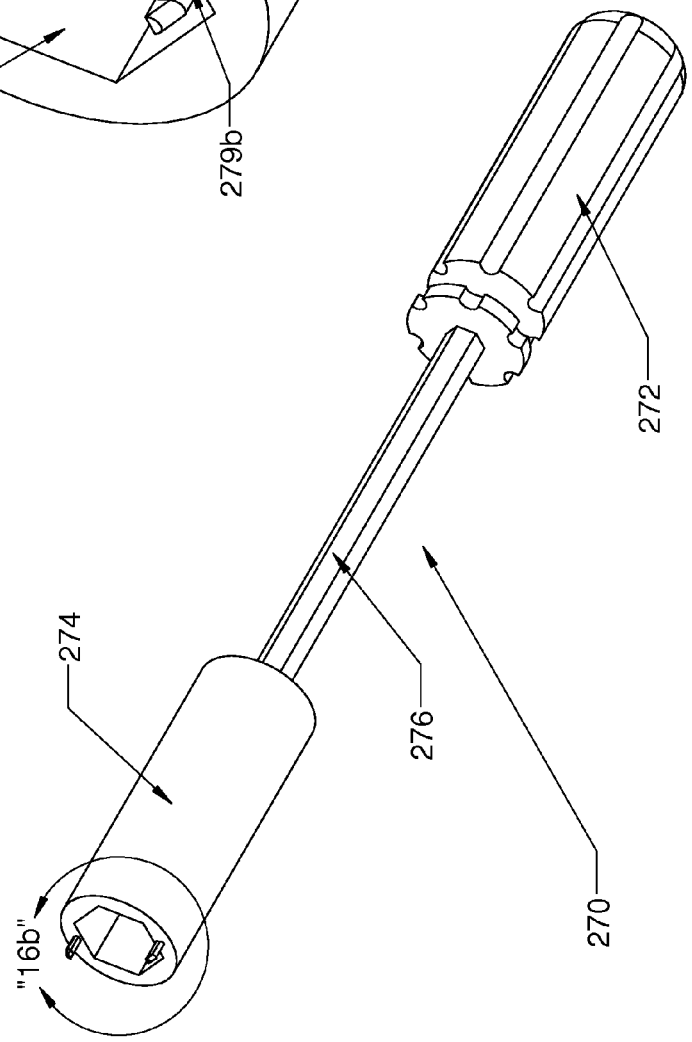

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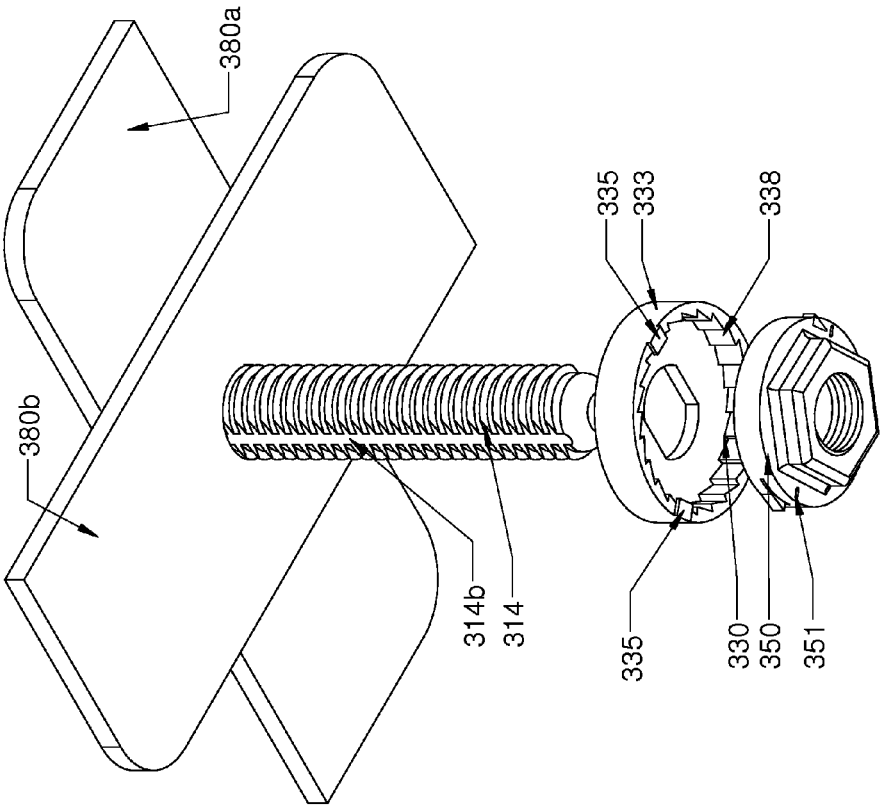
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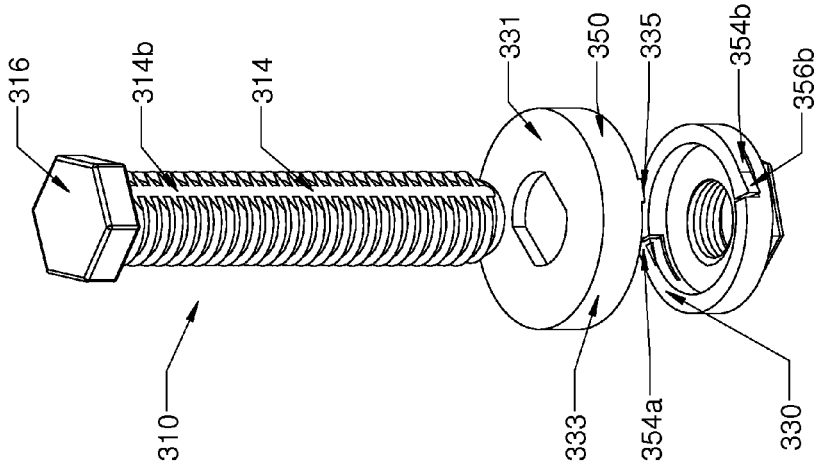
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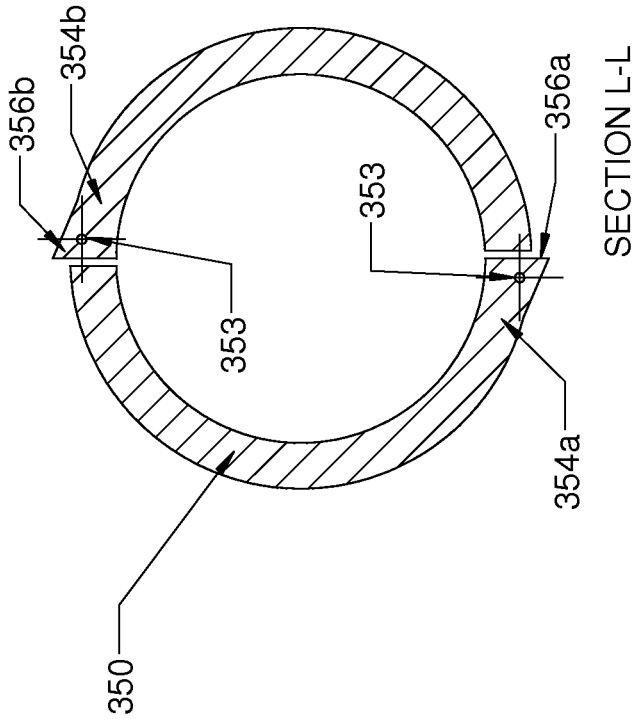
Fig. 17



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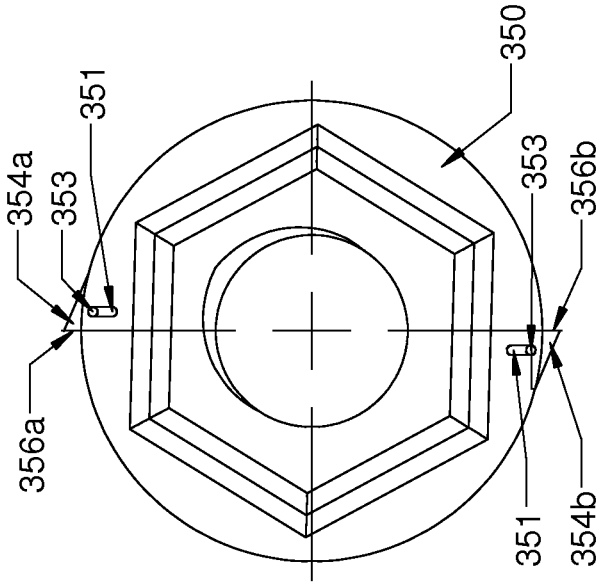

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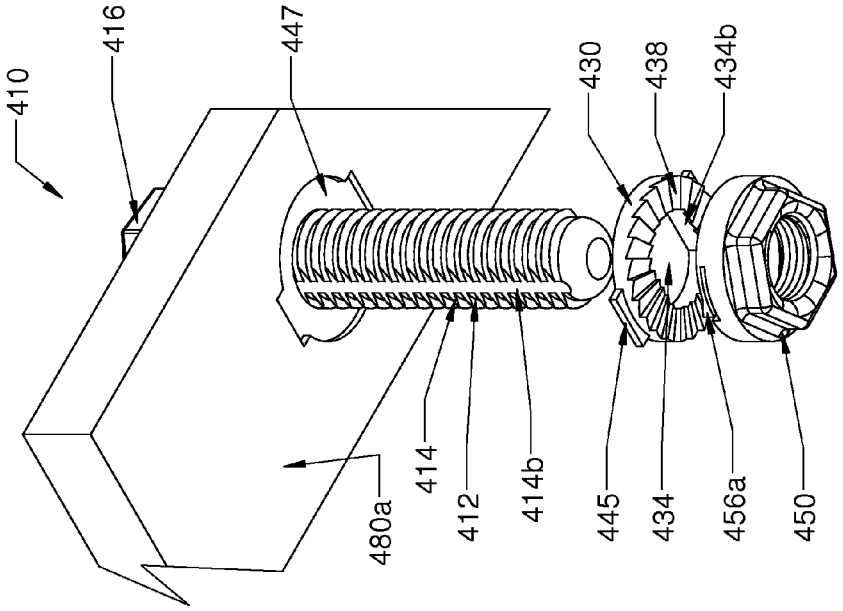
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Fig. 21

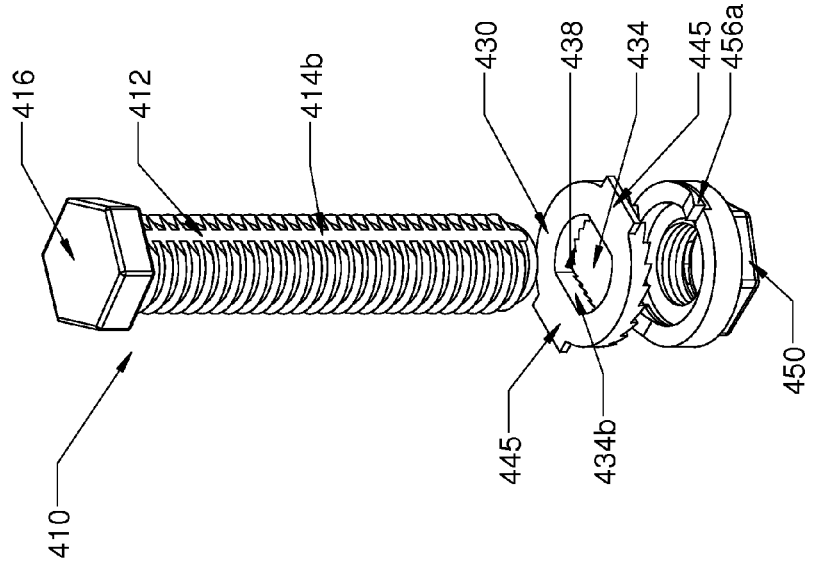
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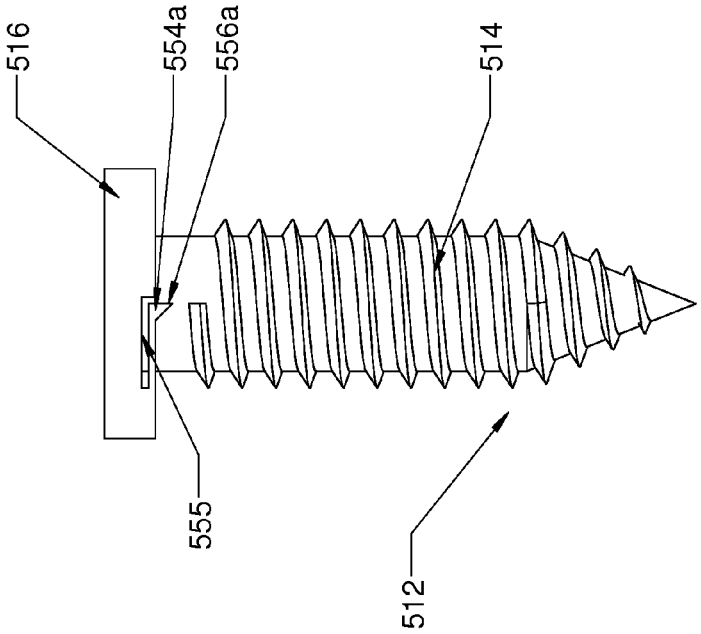
Fig. 20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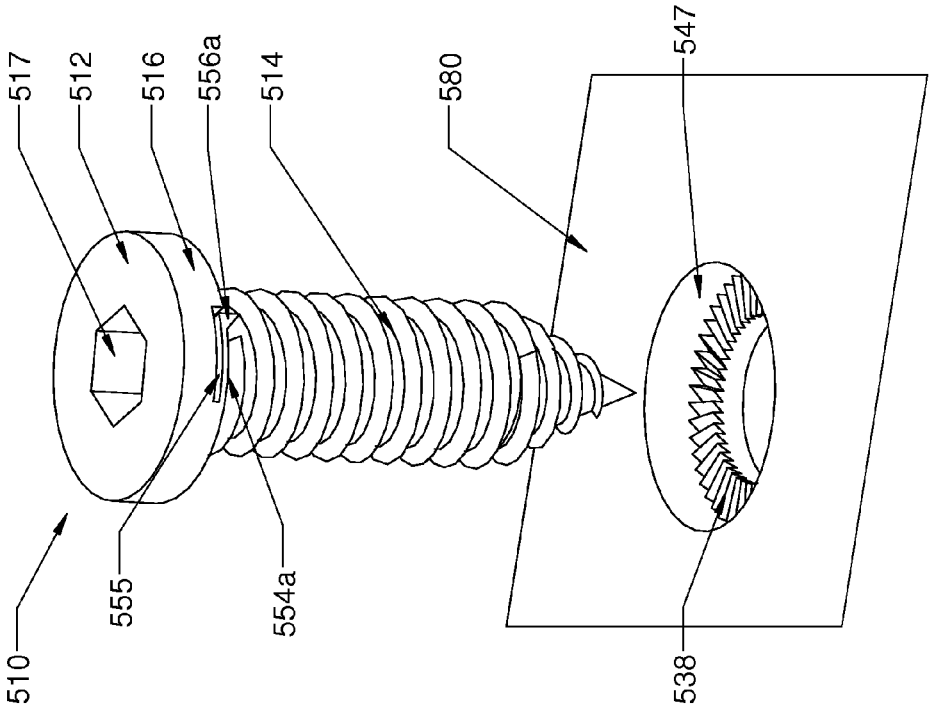
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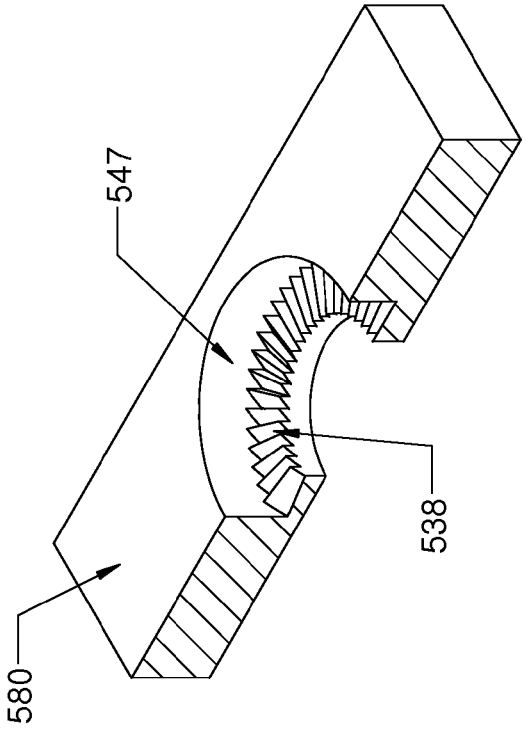
Fig. 22



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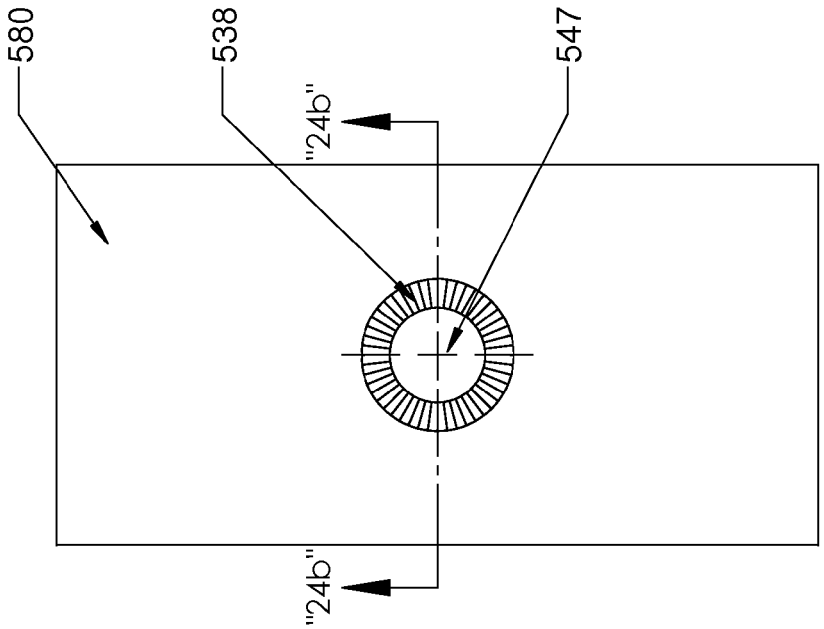

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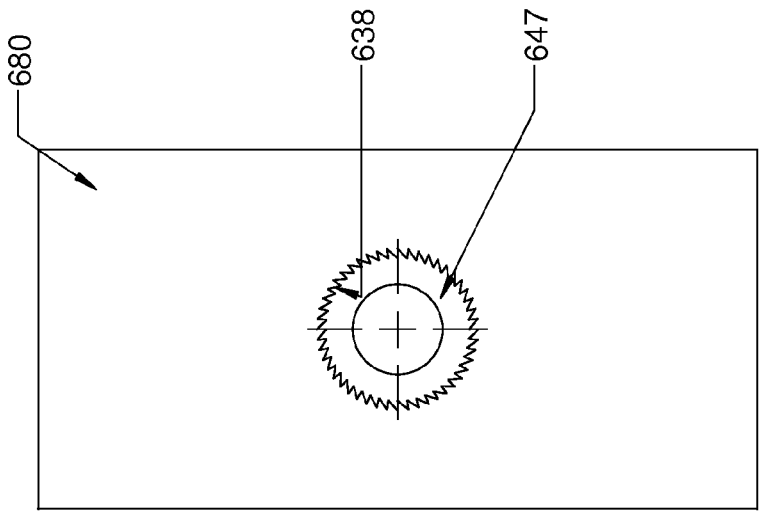

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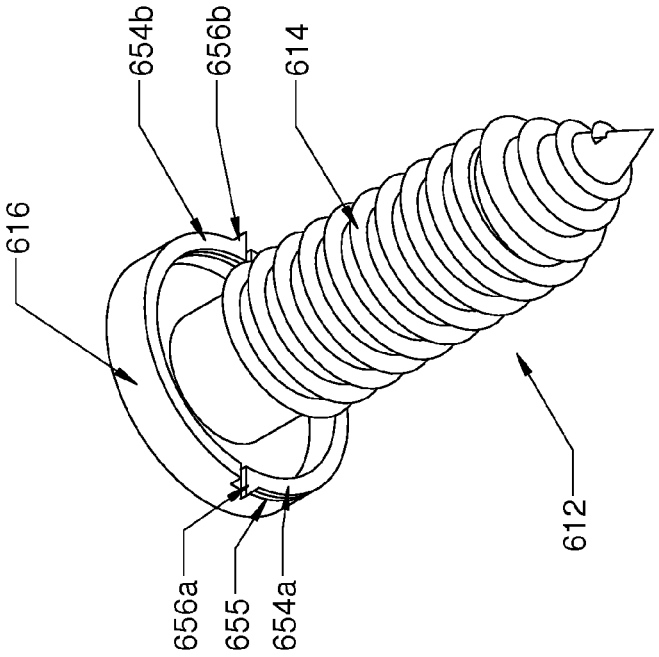

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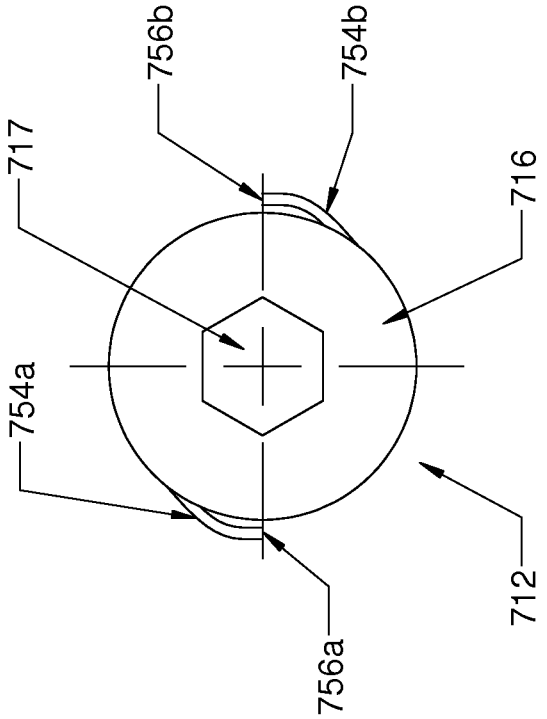

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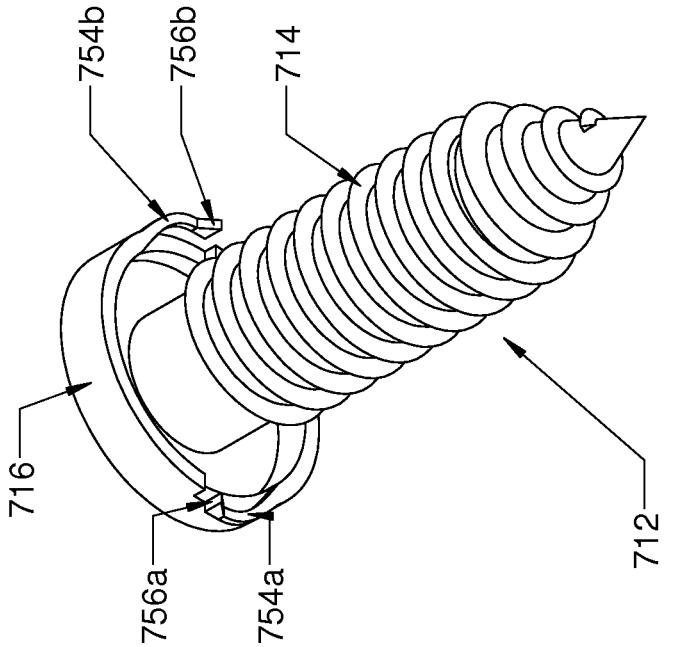

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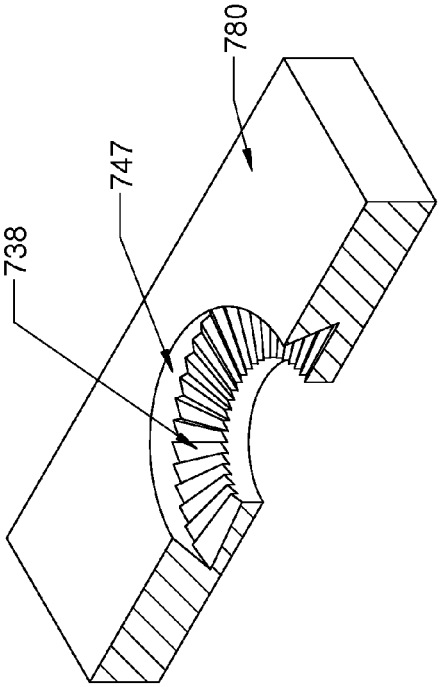

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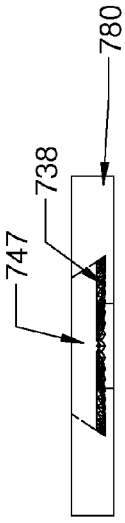

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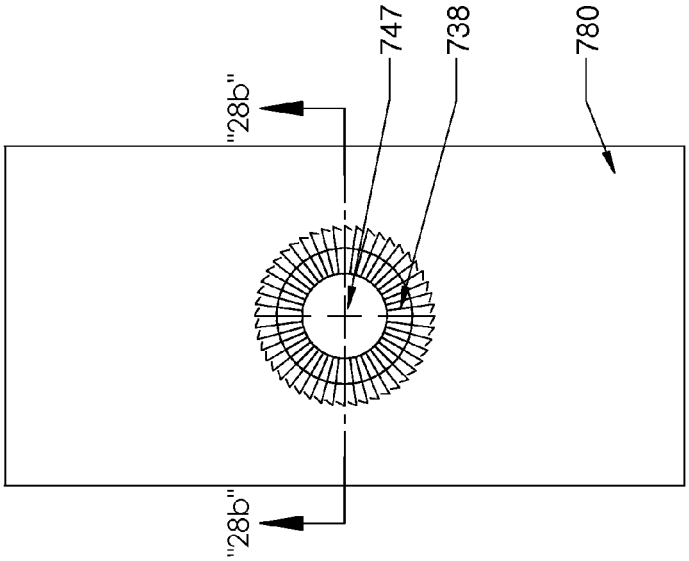

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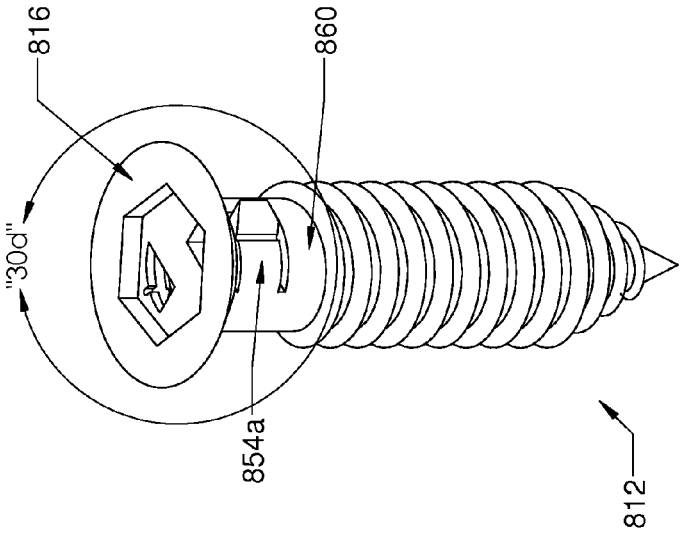

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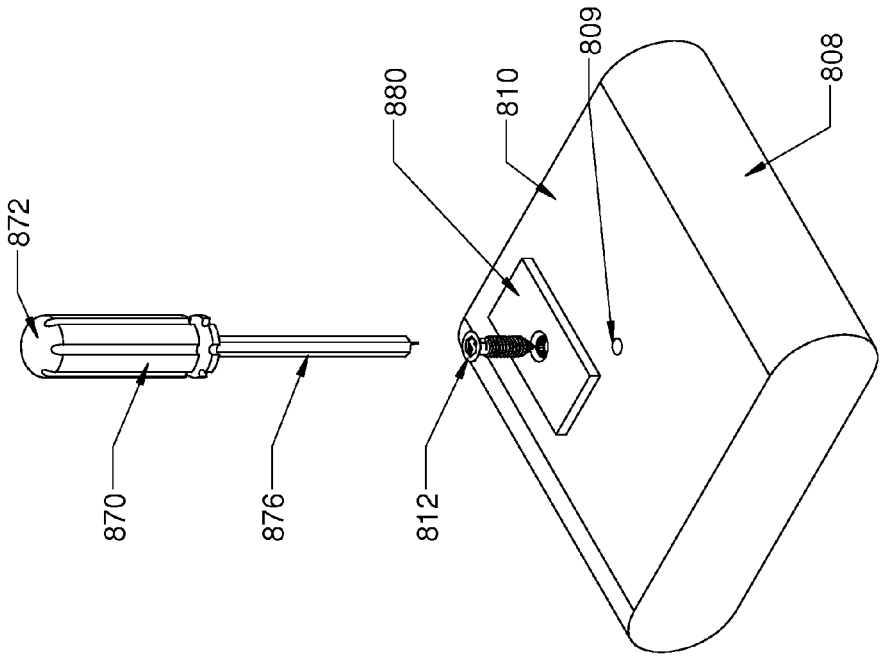

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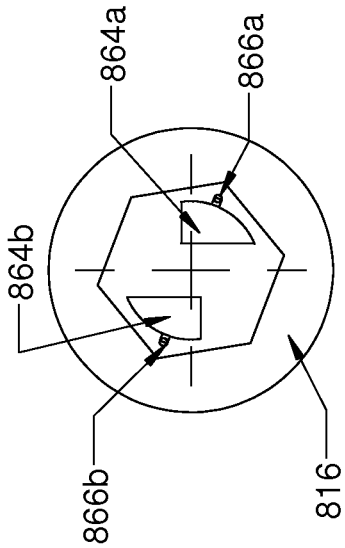

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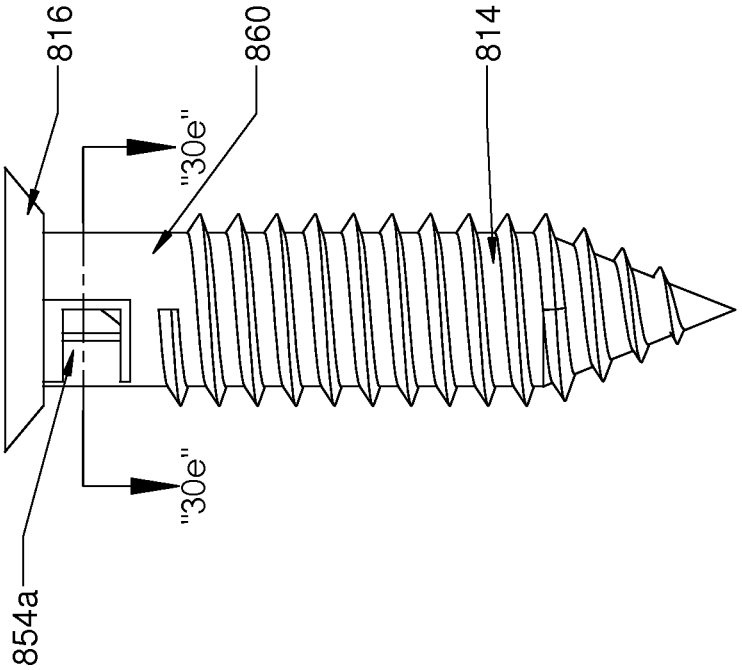

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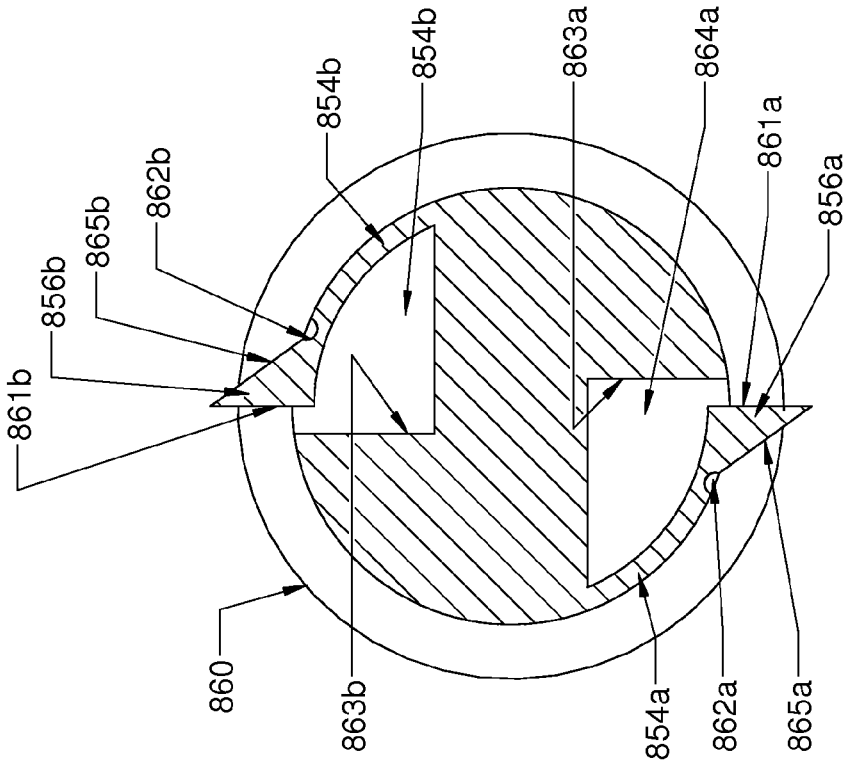

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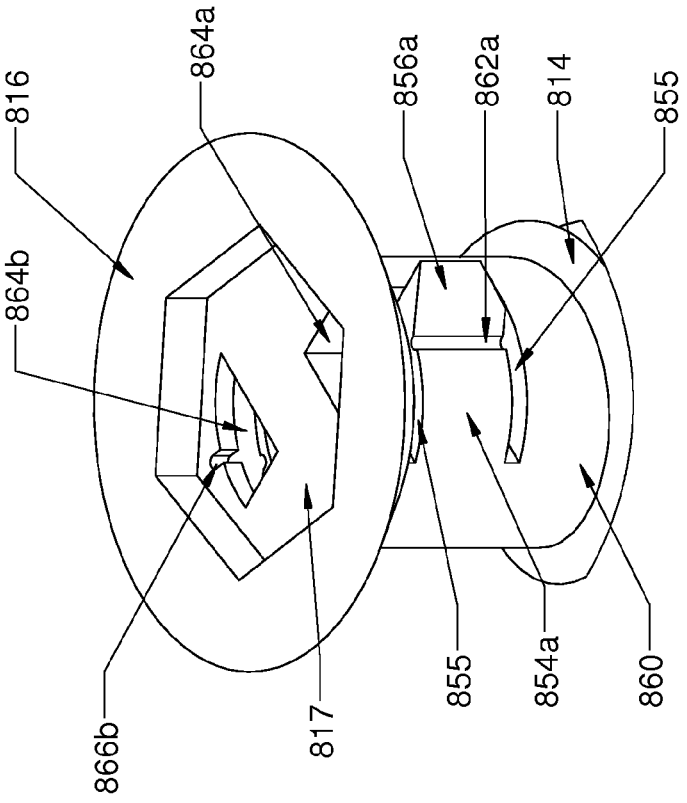

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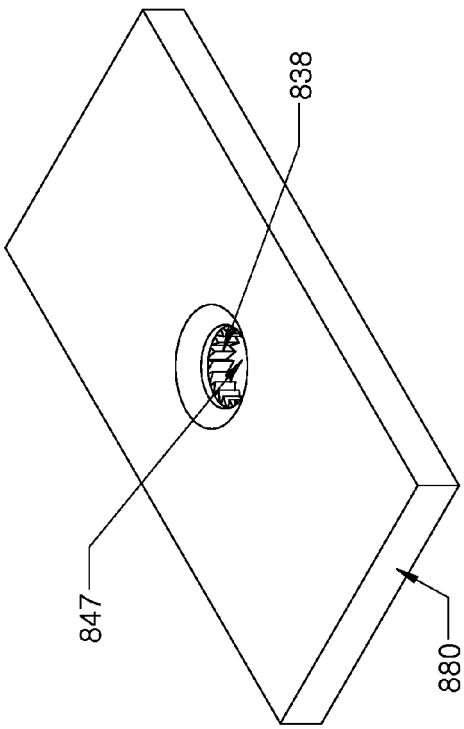

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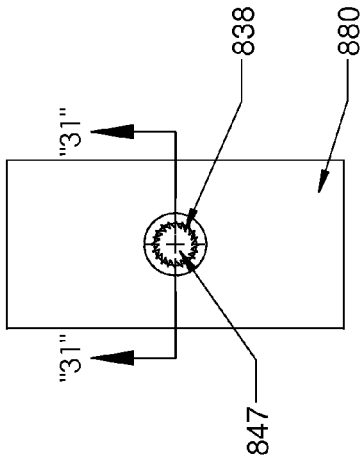

Fig. 31b

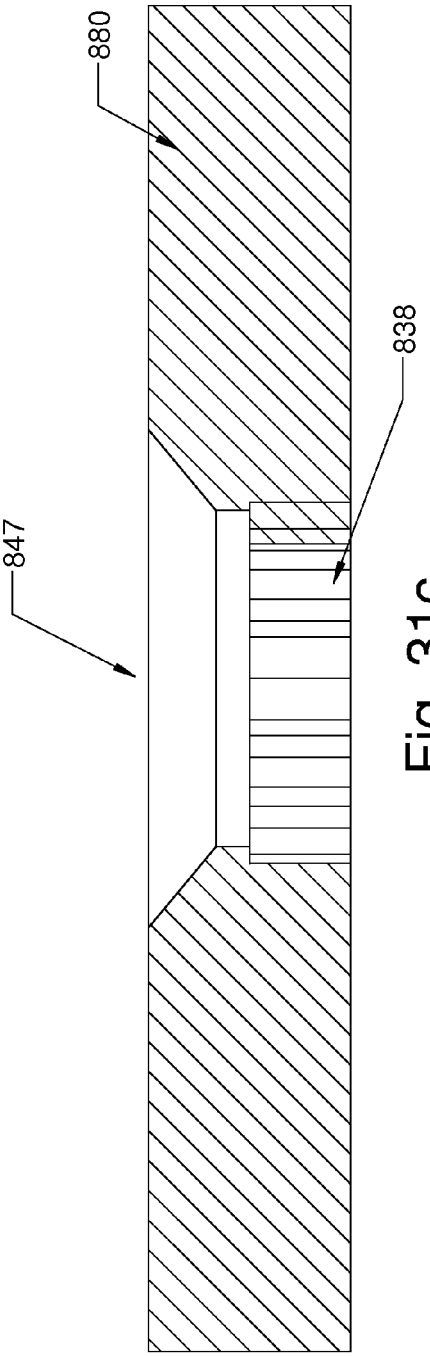

Fig. 31c

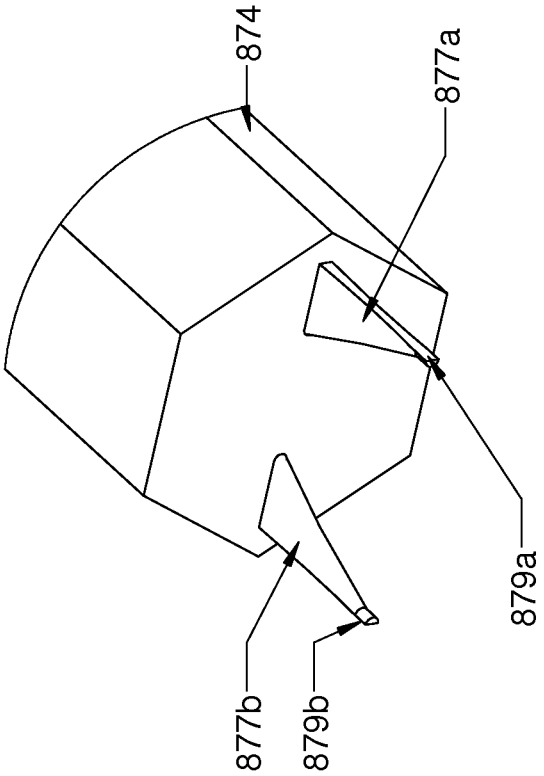

Fig. 32b

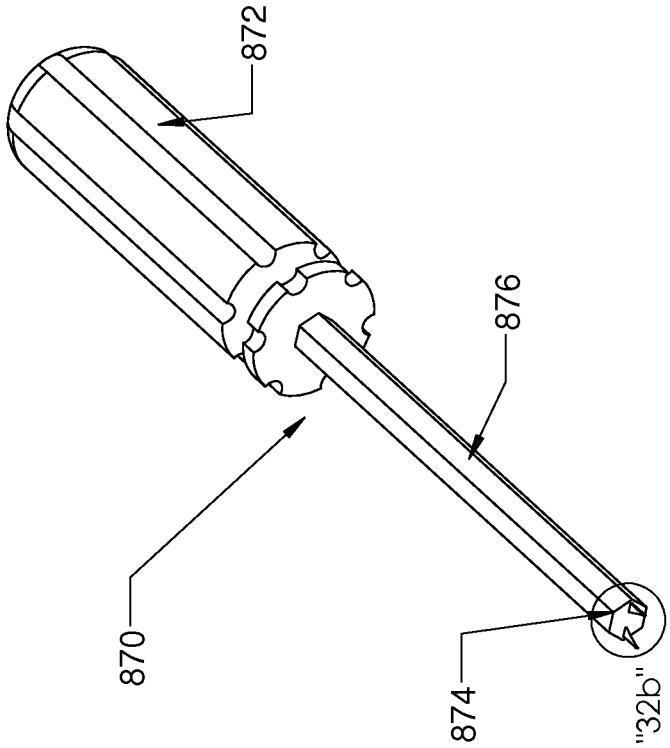

Fig. 32a

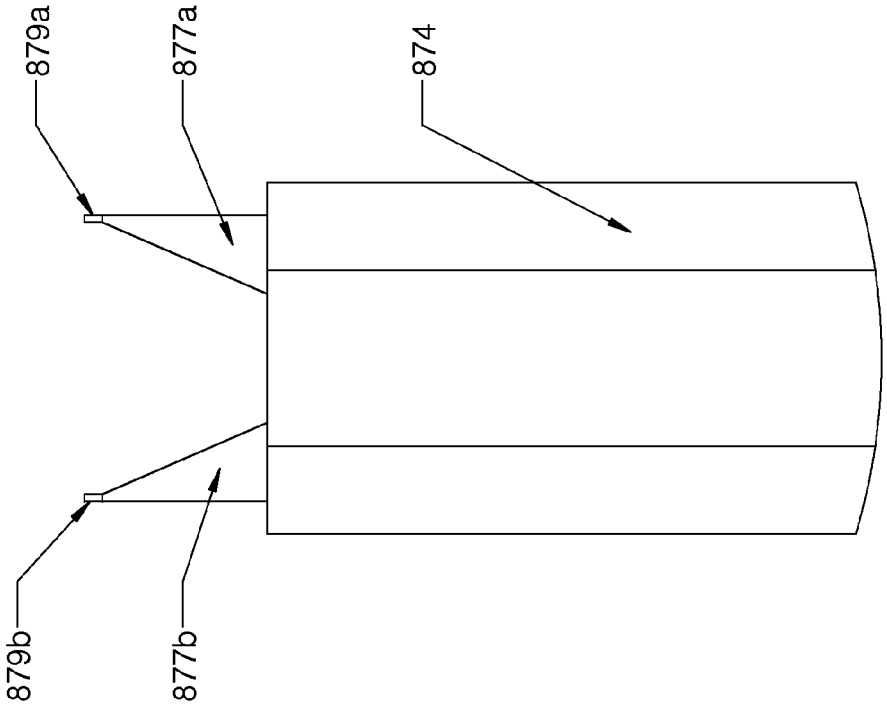

Fig. 32d

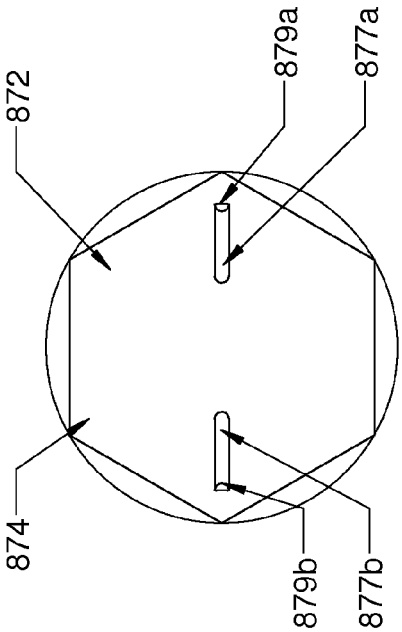

Fig. 32c

RATCHET LOCKING MECHANISM FOR THREADED FASTENER

CROSS-REFERENCE TO RELATED APPLICATION

This application claims priority to U.S. Provisional Patent Application No. 61/403,332 filed Sept. 14, 2010 and U.S. patent application Ser. No. 13/068,171 filed on May 4, 2011, which are incorporated herein by reference.

Background Of Invention

1. Field of the Invention

The subject invention is directed generally to fasteners, and more particularly, to a ratcheting locking mechanism for threaded fasteners.

2. Background of the Related Art

Threaded fasteners designed to lock male and female threaded components together are well known in the art and include, for example, lock washers, blind thread bores filled with resilient inserts and screw thread profiles that deform when tightened. Fasteners with self-locking accessories such as cotter pins and lock wires are also known. Other examples of self-locking threaded fasteners are disclosed in U.S. Pat. No. 5,460,468 to DiStacio on Oct. 24, 1995; U.S. Pat. No. 5,538,378 to Van der Drift on Jul. 23, 1996; and U.S. Pat. No. 5,713,708 to Van der Drift et al. on Feb. 3, 1998, each of which is incorporated herein by reference.

SUMMARY OF THE INVENTION

One embodiment of the subject technology is directed to a fastening device including a fastener having a head portion and an elongated threaded body portion extending axially from the head portion. The threaded body portion includes at least one longitudinally extending flat section. The fastening device also includes a lock washer having opposed upper and lower surfaces, wherein the lower surface has an array of radially extending engagement teeth. The lock washer also forms an axial aperture for receiving the threaded body portion of the fastener. The axial aperture has at least one flat inner surface cooperating with the at least one longitudinally extending flat section of the threaded body portion to prevent relative rotation of the washer and threaded body portion. The fastening device further includes a threaded lock nut for rotatably mating with the threaded body portion. The lock nut has opposed upper and lower surfaces. The upper surface of the threaded lock nut has at least one flexible pawl member for ratcheted engagement with the array of radially extending engagement teeth on the lower surface of the lock washer.

In another embodiment, the subject technology is directed to a fastening device including a fastener having a head portion and an elongated threaded body portion extending axially from the head portion. A lock member has a lower surface with a plurality of ratchet teeth. The lock member couples to the body portion for axial movement but is fixed rotationally. A threaded lock nut rotatably mates with the threaded body portion. The lock nut has an upper surface having at least one pawl tooth for engagement with the plurality of ratchet teeth. The lock member may have an axial aperture having at least one flat inner surface cooperating with the at least one longitudinally extending flat section of the threaded body portion. The lock member may be integral with the head portion. In one embodiment, the fastening device includes a plate defining a recess, wherein the lock member couples into the recess to be fixed rotationally.

In still another embodiment, the subject technology is directed to a fastening device including a fastener having a head portion and an elongated threaded body portion extending axially from the head portion. At least one fastener tooth couples to the fastener in a rotationally fixed manner. A locking structure has at least one locking tooth for ratchet engagement with the at least one fastener tooth. The at least one fastener tooth may be on a distal end of a pawl arm extending from the head portion or on a lock washer that is keyed to the fastener. The at least one fastener tooth may be a plurality of ratchet teeth. The at least one locking tooth may also be on a distal end of a pawl arm extending from the locking structure. Alternatively, the locking structure is a plate having an axial recess and the at least one locking tooth is a plurality of radially extending ratchet teeth facing a lower surface of the head portion.

Additional aspects and advantages of the present disclosure will become readily apparent to those skilled in this art from the following detailed description, wherein only exemplary embodiments of the present disclosure are shown and described, simply by way of illustration of the best mode contemplated for carrying out the present disclosure. As will be realized, the present disclosure is capable of other and different embodiments, and its several details are capable of modifications in various obvious respects, all without departing from the disclosure. Accordingly, the drawings and description are to be regarded as illustrative in nature, and not as restrictive.

BRIEF DESCRIPTION OF THE DRAWINGS

So that those having ordinary skill in the art to which the subject invention pertains will more readily understand how to make and use the fastening device of the subject invention, preferred embodiments thereof will be described in detail hereinbelow with reference to the following drawings.

FIG. **1** is a side elevational view of the fastening device of the subject technology in an assembled condition, wherein the lock washer and lock nut are positioned on the body of the fastener.

FIG. **2** is a perspective view of the fastening device of the subject technology, with the lock washer and lock nut axially aligned and separated from the fastener body for ease of illustration.

FIG. **3** is a perspective view of the fastening device of the subject technology, as viewed from above, with the lock washer and locking nut axially separated and displaced from the fastener body for ease of illustration.

FIG. **4** is a perspective view of the fastening device of the subject technology, as viewed from below, with the lock washer and locking nut axially separated and displaced from the fastener body for ease of illustration.

FIG. **5** is an end view of a plurality of configurations of elongated threaded body portions for use with fastening devices of the subject technology.

FIG. **6** is a side view of another fastening device of the subject technology assembled to fixedly retain to exemplary plate structures.

FIG. **7** is a bottom view of the fastening device of FIG. **6**.

FIG. **8** is a sectional view taken along line "**8**"-"**8**" of FIG. **7**.

FIG. **9** is an enlarged detailed view of the area in circle "**9**" of FIG. **6**.

FIG. **10** is a top perspective view of the fastening device of FIG. **6**, with the lock washer and locking nut axially aligned and separated from the fastener body for ease of illustration.

FIG. **11** is a bottom perspective view of the fastening device of FIG. **6**, with the threaded body portion extending through a plate and the lock washer and lock nut axially aligned and separated from the fastener body for ease of illustration.

FIG. **12** is a side view of another fastening device of the subject technology assembled to fixedly retain to exemplary plate structures.

FIG. **13** is an enlarged detailed view of the area in circle "**13**" of FIG. **12**.

FIG. **14** is a top perspective view of the fastening device of FIG. **12**, with the lock washer and locking nut axially aligned and separated from the fastener body for ease of illustration.

FIG. **15** is a bottom perspective view of the fastening device of FIG. **12**, with the plate, the lock washer, and the lock nut axially aligned and separated from the fastener body for ease of illustration.

FIG. **16***a* is a perspective view of a tool for assembling and/or disassembling the fastening device of FIG. **12**.

FIG. **16***b* is an enlarged detailed view of the area in circle "**16***b*" of FIG. **16***a*.

FIG. **17** is a top perspective view of still another fastening device with the lock washer and locking nut axially aligned and separated from the fastener body for ease of illustration.

FIG. **18** is a bottom perspective view of the fastening device of FIG. **17**, with the lock washer, and the lock nut axially aligned and separated from the fastener body for ease of illustration.

FIG. **19***a* is a top view of a locking nut of the fastening device of FIG. **17**.

FIG. **19***b* is a cross-sectional view of a locking nut of the fastening device of FIG. **17**.

FIG. **20** is a top perspective view of yet another fastening device of the subject technology utilizing a lock plate.

FIG. **21** is a bottom perspective view of the fastening device of FIG. **20**.

FIG. **22** is a top perspective view of yet still another fastening device with the pawl integral to the head of the threaded fastener in accordance with the subject technology.

FIG. **23** is a side view of a threaded fastener with the ratchet integral thereto for the fastening device of FIG. **22**.

FIG. **24***a* is a top view of a plate structure with the ratchet integral thereto for the fastening device of FIG. **22**.

FIG. **24***b* is a cross-sectional side view of the plate structure of FIG. **24***a* taken along line "**24***b*"-"**24***b*".

FIG. **25** is a bottom perspective view of yet still another fastener with the pawl integral to the head thereof for a radial engagement configuration in accordance with the subject technology.

FIG. **26** is a top view of a plate structure with the ratchet integral thereto for use with the fastener of FIG. **25**.

FIG. **27***a* is a bottom perspective view of yet still another fastener with the pawl integral to the head thereof for a radial engagement configuration in accordance with the subject technology.

FIG. **27***b* is a top view of the fastener of FIG. **27***a*.

FIG. **28***a* is a top view of a plate structure with the ratchet integral thereto for use with the fastener of FIG. **27***a*.

FIG. **28***b* is a sectional view of the plate structure of FIG. **28***a* taken along line "**28***b*"-"**28***b*".

FIG. **28***c* is a sectional perspective view of the plate structure of FIG. **28***a*.

FIG. **29** is a top perspective view of yet still another fastening device aligned with a driving tool for inserting and removing the fastener in accordance with the subject technology.

FIG. **30***a* is a perspective view of the fastener of FIG. **29**.

FIG. **30***b* is a side view of the fastener of FIG. **29**.

FIG. **30***c* is a top view of the fastener of FIG. **29**.

FIG. **30***d* is an enlarged perspective view of the area in circle "**30***d*" of the fastener in FIG. **30***a*.

FIG. **30***e* is a sectional view of the fastener of FIG. **30***b* taken along line "**30***e*"-"**30***e*".

FIG. **31***a* is a perspective view of the plate structure of FIG. **29**.

FIG. **31***b* is a top view of the plate structure of FIG. **31***a*.

FIG. **31***c* is a sectional view of the plate structure of FIG. **31***b* taken along line "**31***c*"-"**31***c*".

FIG. **32***a* is a perspective view of the driving tool of FIG. **29**.

FIG. **32***b* is an enlarged perspective view of the area in circle "**32***a*" of the driving tool in FIG. **32***a*.

FIG. **32***c* is a top view of the driving tool of FIG. **29**.

FIG. **32***d* is a side view of the driving tool of FIG. **29**.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

The present disclosure overcomes many of the prior art problems associated with threaded fasteners. In general, threaded fasteners are used to fixedly connect two or more pieces in a variety of applications such as, without limitation, with surgical implants, industrial applications, and building applications. Among other features and benefits, the disclosed ratchet locking mechanisms for threaded fasteners facilitate quick and easy installation while providing a reliably secured tightness with the ability to remove the fastener if desired. The advantages, and other features of the technology disclosed herein, will become more readily apparent to those having ordinary skill in the art from the following detailed description of certain preferred embodiments taken in conjunction with the drawings which set forth representative embodiments of the present invention and wherein like reference numerals identify similar structural elements.

All relative descriptions herein such as upward, downward, left, right, up, down, length, height, width, thickness and the like are with reference to the Figures, and not meant in a limiting sense. Additionally, the illustrated embodiments can be understood as providing exemplary features of varying detail of certain embodiments, and therefore, features, components, modules, elements, and/or aspects of the illustrations can be otherwise combined, interconnected, sequenced, separated, interchanged, positioned, and/or rearranged without materially departing from the disclosed fastener assemblies. Additionally, the shapes and sizes of components are also exemplary and can be altered without materially affecting or limiting the disclosed technology.

Referring now to FIG. **1**, a fastening device constructed in accordance with a preferred embodiment of the subject invention and designated generally by reference numeral **10**. Fastening device **10** includes a threaded fastener **12** in the form of a carriage bolt or the like, which includes an elongated threaded body portion **14** extending from a slotted head portion **16**. Those skilled in the art will readily appreciate that the head portion **16** of fastener **12** could take any conventional form known in the art including, for example, a hexagonal head.

With additional reference to FIGS. **2** through **4**, fastening device **10** further includes an annular lock washer **30** having opposed upper and lower surfaces **32***a*, **32***b*, and an axial aperture **34** for receiving the threaded body portion **14** of fastener **12**. It is envisioned that the lock washer **30** is a split washer defining a radial gap **35**. However, the lock washer **30** may be a continuous ring. The threaded body portion **14**

includes a pair of diametrically opposed, longitudinally extending flat sections **14***a*, **14***b* and the axial aperture **34** of lock washer **30** includes a pair of diametrically opposed flat surfaces **34***a*, **34***b*. The longitudinally extending flat sections **14***a*, **14***b* of the threaded body portion **14** and the flat surfaces **34***a*, **34***b* of aperture **34** cooperate to inhibit rotational movement of the lock washer **30** relative to the threaded body portion **14**, while permitting axial movement of the lock washer **30** relative to the threaded body portion **14** during placement of the fastening device **10** in a structure. The lower surface **32***b* of lock washer **30** includes an array of circumferentially disposed, radially extending engagement teeth **38**, effectively defining an annular rack or ratchet gear. Each tooth **38** is triangular in shape and, preferably, substantially a right triangle with a hypotenuse **38***a* facing generally axially and a leg **38***b* being substantially parallel to the threaded body portion **14** when engaged.

Fastening device **10** further includes a locking nut **50** that is threadably associated with the threaded body portion **14** of fastener **12** and includes opposed upper and lower surface portions **52***a*, **52***b*. The upper surface portion **52***a* of locking nut **50** includes a pair of diametrically opposed, cantilevered arcuate pawl arms **54***a*, **54***b*. The pawls arms **54***a*, **54***b* have pawl teeth pairs **56***a*, **56***b*, respectively, that are configured for ratcheted engagement with the array of radial engagement teeth **38** on the lower surface **32***b* of lock washer **30**. The lower surface portion **52***b* of lock nut **50** defines a hexagonal fitting **55** for interaction with a turning tool such as a conventional wrench or socket (not shown). It should be readily appreciated that preventing the lock washer **30** from rotating on the threaded body portion **14** of fastener **12**, while allowing the lock washer **30** to freely travel longitudinally on the body portion **14**, allows the lock nut **50** to engage the washer **30**, but the nut **50** cannot loosen once the ratcheting pawl arms **54***a*, **54***b* of the nut **50** engage the radial teeth **38** of the washer **30** in a tight manner. The pawl teeth pairs **56***a*, **56***b* can slide across the hypotenuse **38***a* of the ratchet teeth **38** during tightening but are prevented from backing up by engagement with the leg **38***b* of the ratchet teeth **38**.

Those skilled in the art will readily appreciate that while the means for preventing the lock washer **30** from rotating relative to the threaded body **14** has been illustrated and described as a pair of diametrically opposed flat sections **14***a*, **14***b* on the body and corresponding flat surfaces in the washer aperture **34**, other means can also be employed to prevent rotation of the lock washer **30** relative to the threaded body **14**. For example, there could be one flat section on the threaded body **14** and one flat surface in the aperture **34** of washer **30**. There could be three or more flat sections on the threaded body **14** and a corresponding number of flat sections in the aperture **34** of the washer **30**. Alternatively, the body **14** could include one or more longitudinal concavities and one or more corresponding convexities on the inner diameter of the washer **30**.

Referring now to FIG. **5**, an end view of a plurality of configurations of elongated threaded body portions **14** for use with fastening devices is shown for further illustration. Each column **60***a-e* utilizes a different configuration of locking feature **64***a-e* and each row **62***a-d* varies the number of times that the locking feature is utilized. As can be seen, the threaded body portion **14** in row **62***b* and column **60***a* is shown in FIGS. **1-4**. The locking feature **64***a* is basically a flat portion that is utilized once (row **62***a*, column **60***a*) or repeated various times although for simplicity only a maximum of four repetitions (row **62***d*, column **60***a*) are shown. Similarly the other locking features of a circular cut (column **60***b*), a groove cut (column **60***c*), a wedge or keyhole cut (column **60***d*), or a triangular cut (column **60***e*) and the like can be utilized any number of times.

Now referring to FIG. **6**, a side view of another fastening device **110** of the subject technology assembled is shown. As will be appreciated by those of ordinary skill in the pertinent art, the fastening device **110** utilizes similar principles to the fastening device **10** described above. Accordingly, like reference numerals preceded by the numeral "1" are used to indicate like elements. The following description is directed to the primary differences of the fastening device **110**, which in comparison to the fastening device **10** is the use of a hex head **116** on the threaded fastener **112**, a single pawl tooth **156***a*, **156***b* on each pawl arm **154***a*, **154***b* of the locking nut **150**, and a solid ring lock washer **130**. The fastening device **110** is shown fixedly retaining two exemplary plate structures **180***a*, **180***b*. It is also noted that a slot **155** to create a flexibility in the pawl arm **154***a* is also relatively shorter in the fastening device **110** as compared with the fastening device **10** shown above. FIGS. **7-11** illustrate various other views to more fully appreciate the structure and operation of the fastening device **110**.

Referring now particularly to FIG. **9**, an enlarged detailed view of the area in circle "**9**" of FIG. **6** is shown to illustrate the pawl tooth **156***a* of the pawl arm **154***a* engaged in the teeth **138** of the lock washer **130**. The pawl tooth **156***a* is configured to also have a leg **157***b* flush against the leg **138***b* of the corresponding ratchet tooth **138** to prevent loosening of the lock nut **130**. However, a hypotenuse **157***a* of the pawl tooth **156***a* may still move forward over the hypotenuse **138***a* of the ratchet tooth **138** by deflection of the pawl arm **154***a* into the pawl slot **155**. It is also envisioned that a radial hole or other feature can be provided in the pawl teeth **156***a*, **156***b* so that the pawl teeth **156***a*, **156***b* may be pushed or pulled downward into the pawl slot **155** in order to allow the lock nut to be removed after tightening.

Now referring to FIG. **12**, a side view of another fastening device **210** of the subject technology assembled is shown. As will be appreciated by those of ordinary skill in the pertinent art, the fastening device **210** utilizes similar principles to the fastening devices **10**, **110** described above. Accordingly, like reference numerals preceded by the numeral "2" are used to indicate like elements. The following description is directed to the primary difference of the fastening device **210**, which in comparison to the fastening devices **10**, **110** is a radial arrangement of the ratchet teeth **238** and pawl teeth **256***a*, **256***b* as opposed to a face to face arrangement.

Referring now to FIGS. **14** and **15**, top and bottom perspective views of the fastening device **210**, with the lock washer **230** and locking nut **250** axially aligned and separated from the fastener body **214**, are shown, respectively. The lock washer **230** includes an optional base plate **231** with which the lock washer ratchet teeth **238** are integral. The teeth **238** are located on the outer circumference of the lower portion **233** of the lock washer **238**.

The locking nut **250** forms a cavity **235** into which the lower portion **233** of the lock washer **230** fits so that the base plate **231** rests against the locking nut **250** and the lock washer ratchet teeth **238** are aligned with the locking nut pawl teeth **256***a*, **256***b*. In one embodiment, the fit between the lock washer **230** and locking nut **250** is such that the combination may be sold and treated during installation as an integral unit. In such a case, distal curved hooks **237** on the pawl arms **254***a*, **254***b* allow using a tool (see FIG. **16***a*) to splay the pawl arms **254***a*, **254***b* radially outward during insertion of the lock washer **230**. The same tool may also be utilized to splay the pawl arms **254***a*, **254***b* radially outward in order to remove the locking nut **250** after tightening.

Referring now particularly to FIG. **13**, an enlarged detailed view of the area in circle "**13**" of FIG. **12** is shown to illustrate the lock washer **230** and locking nut **250** after assembly and tightening of the fastening device **210**. When assembled, the ratchet teeth **238** and the locking nut pawl teeth **256***a*, **256***b* again form a ratchet and pawl that allows tightening of the fastening device **210** but prevents loosening due to the interaction between the lock washer **230** and locking nut **250**. During tightening, as the locking nut **250** rotates about the lock washer **230**, the pawl arms **254***a*, **254***b* deflect radially outward to traverse across the teeth **238** of the lock washer **230**. However, the configuration of the ratchet and pawl is such that travel only proceeds in the tightening direction without undue force.

Referring now to FIGS. **16***a* and **16***b*, perspective and enlarged detailed views of a tool **270** for assembling and/or disassembling the fastening device **210** are shown, respectively. The tool **270** has a shaft **276** extending between a proximal handle **272** and a distal working portion **274**. The distal working portion **274** includes a socket aperture **278** for coupling to the locking nut **250** in a traditional manner. The working portion **274** also include diametrically opposed posts **279***a*, **279***b* that couple into the curved hooks **237** on the pawl arms **254***a*, **254***b* such that upon loosening the locking nut **250** with the tool **270**, the pawl arms **254***a*, **254***b* are flexed radially outward to disengage the ratchet and pawl mechanism.

Now referring to FIGS. **17** and **18**, top and bottom perspective exploded views of another fastening device **310** of the subject technology are shown. As will be appreciated by those of ordinary skill in the pertinent art, the fastening device **310** utilizes similar principles to the fastening devices **10**, **110**, **210** described above. Accordingly, like reference numerals preceded by the numeral "3" are used to indicate like elements. The following description is directed to the primary difference of the fastening device **310**, which in comparison to the fastening devices **210** is a varied configuration of the locking washer **330** and lock nut **350**.

The lock washer **330** includes a base plate **331** with an annular wall **333** extending therefrom. The lock washer ratchet teeth **338** are formed on the inner radius of the annular wall **333**. Three optional flanges **335** extend from the lower end of the annular wall **333** to facilitate retaining the locking nut **350** therein.

The locking nut **350** is sized to fit within the annular wall **333** of the lock washer **330** so that the lock washer ratchet teeth **338** are aligned with the locking nut pawl teeth **356***a*, **356***b*. In one embodiment, the optional flanges **335** are welded into place after assembly to permanently fix the lock washer **330** and locking nut **350** as an assembly.

Referring now to FIGS. **19***a* and **19***b*, top and cross-sectional views of the locking nut **350** are shown, respectively. It is noted that the cross-sectional view of FIG. **19***b* passes through the pawl arms **354***a*, **354***b*. The locking nut **350** defines slotted apertures **351** aligned with circular holes **353** in the pawl arms **354***a*, **354***b*. Consequently, a removal tool (not shown) may include two posts that can be inserted through the slotted apertures **351** into the circular holes **353**. As the two posts are moved radially inward, the pawl arms **354***a*, **354***b* splay radially inward to remove the pawl teeth **356***a*, **356***b* from the ratchet teeth **338** of the lock washer **330** in order to remove the locking nut **350** after tightening.

Now referring to FIGS. **20** and **21**, top and bottom perspective exploded views of another fastening device **410** of the subject technology are shown. As will be appreciated by those of ordinary skill in the pertinent art, the fastening device **410** utilizes similar principles to the fastening devices **10**, **110**, **210**, **310** described above. Accordingly, like reference numerals preceded by the numeral "4" are used to indicate like elements. The following description is directed to the primary difference of the fastening device **410**, which is incorporation of features to rotationally couple the plate structure **480** and the lock washer **430**.

The lock washer **430** includes ratchet teeth **438** but rather than having a cylindrical circumference, the circumference is interrupted by opposing shoulders **445**. The plate structure **480** forms a recess **447** sized and configured to receive the lock washer **430**. Because of the non-cylindrical shapes of the lock washer **430** and recess **447**, the lock washer **430** is stopped from rotational movement therein. As a result, the flat section **414***b* of the threaded body portion **414** is optional. During deployment, the ratchet and pawl operation between the lock washer **430** and locking nut **450** occurs equally as effectively as noted above with just the recess **447** of the plate structure **480** preventing lock washer **430** rotation.

Now referring to FIG. **22**, a top perspective exploded view of another fastening device **510** of the subject technology is shown. As will be appreciated by those of ordinary skill in the pertinent art, the fastening device **510** utilizes similar principles to the fastening devices **10**, **110**, **210**, **310**, **410** described above. Accordingly, like reference numerals preceded by the numeral "5" are used to indicate like elements. The following description is directed to the primary difference of the fastening device **510**, which is incorporation of pawl arms **554***a*, **554***b* into the fastener head **516**.

Referring additionally now to FIG. **23**, a side view of the threaded fastener **512** is shown. The fastener head **516** defines the pawl arms **554***a*, **554***b* in an outer circumference thereof. The fastener head **516** also defines a hexagonal axial recess **517**, best seen in FIG. **22**, for cooperating with an allen wrench or like driving tool (not shown).

Referring now to FIGS. **24***a* and **24***b*, top and cross-sectional views of the plate structure **580** are shown. The plate structure **580** incorporates the ratchet teeth **538** into the bottom of a recess **547**. It is envisioned that the plate structure **580** can be any shape or configuration such as a bar, band, plate and the like depending upon the desired application.

Referring again to FIG. **22**, the threaded body portion **514** is a self tapping design so that the fastener **512** can pass through the plate structure **580** and threadably engage a structure opposite thereto. In an alternative embodiment, the threaded body portion **514** has machine threads that mate into machine threads of the plate structure **580**. Upon the fastener head **516** reaching the ratchet teeth **538** in the plate structure **580**, the teeth **556***a*, **556***b* of the pawl arms **554***a*, **554***b* engage the ratchet teeth **538** to prevent reversal of the fastener **512** in the normal course. In an alternative embodiment, a radial hole is provided in the pawl arms **554***a*, **554***b* to allow inserting a tool and pulling the pawl arms **554***a*, **554***b* upward to disengage the ratchet and pawl, thereby allowing reversal of the fastener **512**.

Now referring to FIGS. **25** and **26**, a bottom perspective exploded view of another fastener **612** and a top view of a plate structure **680** of the subject technology are shown. As will be appreciated by those of ordinary skill in the pertinent art, the fastener **612** and plate structure **680** utilize similar principles to the fastening devices described above and like reference numerals preceded by the numeral "6" are used to indicate like elements. The primary differences relate to providing the ratchet and pawl engagement in a radial manner while incorporating the pawl arms **654***a*, **654***b* into the fastener head **616**.

In the plate structure **680**, the ratchet teeth **638** are again disposed in the recess **647** but located in the sidewall rather than the bottom of the recess **647**. The fastener head **616** is

sized and configured to fit into the recess **647** so that the pawl teeth **656***a*, **656***b* of the pawl arms **654***a*, **654***b* engage with the ratchet teeth **638**.

Now referring to FIGS. **27***a*-**28***c*, various views of another fastener **712** and a plate structure **780** of the subject technology are shown. The primary differences are that the pawl arms **754***a*, **754***b* extend radially outward from the fastener head **716** and the recess **747** has a trapezoidal cross-sectional shape (best seen in FIG. **28***b*). The combination of the radially extended pawl arms **754***a*, **754***b* within the trapezoidal recess **747** may create an effective capture of the fastener head **716** therein so that once combined, the fastener **712** is coupled to the plate structure **780**. A radially engaging ratchet and pawl version could equally as well utilize the radially extended pawl arms.

Now referring to FIG. **29**, a top perspective exploded view of another fastening device **810** being attached to an object **808** in accordance with the subject technology is shown. The object **808** could be any size or shape and preferably includes a pilot hole **809** to facilitate easy insertion of the fastener **812**. As will be appreciated by those of ordinary skill in the pertinent art, the fastening device **810** utilizes similar principles to the fastening devices described above and like reference numerals preceded by the numeral "8" are used to indicate like elements. The following description is directed to the primary differences of the fastening device **810**, which is incorporation of the pawl arms **854***a*, **854***b* into a rim **860** of the threaded body portion **814** of the fastener **812**.

Referring now to FIGS. **30***a-e*, various views of the fastener **812** of FIG. **29** are shown in detail. The rim **860** between the head **816** and body portion **814** includes the pawl arms **854***a*, **854***b*. The pawl arms **854***a*, **854***b* are formed by slots **855** with radially extending distal teeth **856***a*, **856***b*. The pawl arms **854***a*, **854***b* also define an axial slot **862***a*, **862***b* adjacent the teeth **856***a*, **856***b*. As best seen in FIG. **30***e*, the pawl teeth **856***a*, **856***b* are triangular with legs **861***a*, **861***b* and a hypotenuse **865***a*, **865***b* that engage the ratchet teeth **838**.

As best seen in FIGS. **30***c-e*, the fastener head **816** has axial apertures **864***a*, **864***b* that extend at least into if not through the rim **860**. The axial apertures **864***a*, **864***b* also include notches **866***a*, **866***b* that align with the axial slots **862***a*, **862***b* on the pawl arms **854***a*, **854***b* that allow the fastener **812** to be reversible as described below. In an alternative embodiment, the fastener **812** does not have axial slots in the pawl arms or notches in the apertures of the head so that the fastener is not reversible. The fastener head **816** also forms a traditional hexagonal recess **817**.

Referring now to FIGS. **31***a-c*, various views of the plate structure **880** are shown. The plate structure **880** is particularly suited to couple with the fastener **812** to form a ratchet and pawl engagement. The recess **847** is countersunk to compliment the shape of the fastener head **816**. The ratchet teeth **838** are arranged vertically to interact with the pawl arm teeth **856***a*, **856***b* during tightening of the fastener **812**.

Referring now to FIGS. **32***a-d* various views of the driving tool **870** for tightening and removing the fastener **812** are shown. The shaft **872** is hexagonal to couple with the recess **817** of the fastener head **816**. The driving tool **870** includes two projections **877***a*, **877***b* on the distal working portion **874**. Each projection **877***a*, **877***b* includes a tip **879***a*, **879***b* sized to insert into the respective axial slots **862***a*, **862***b* of the pawl arms **854***a*, **854***b* when the projections **877***a*, **877***b* are fully inserted into the axial apertures **864***a*, **864***b* of the fastener head **816**. Once the projections **877***a*, **877***b* are fully inserted, the driving tool **870** can be rotated to tighten or remove the fastener **812** as desired. A standard hex tool can also be used to tighten the fastener **812** with the pawl arm teeth **856***a*, **856** ratcheting on the ratchet teeth **838**.

During tightening the fastener **812**, the driving tool shaft **876** engages the fastener head **816** so that the fastener **812** can be rotated. The fastener **812** would self tap into the object **808** and bring the rim **860** into the recess **847**. In an alternative embodiment, the fastener **812** has machine threads that mate into corresponding machine threads in object **808**. Similar to above, the pawl teeth **856***a*, **856***b* and ratchet teeth **838** would interact to allow tightening but prevent loosening unless the loosening force is applied by the driving tool **870**.

To remove the fastener **812**, the driving tool **870** is fully inserted into the fastener head **816** so that the tips **879***a*, **879***b* of the projections **877***a*, **877***b* press into the axial slots **862***a*, **862***b*. As best envisioned with respect to FIG. **30***e*, a counterclockwise rotation of the driving tool **870** would force the pawl arms **854***a*, **854***b* to deflect radially inward so that the legs **861***a*, **861***b* of the pawl teeth **856***a*, **856***b* move radially inward until touching a sidewall **863***a*, **863***b* of the axial apertures **864***a*, **864***b*. As a result, the pawl teeth **856***a*, **856***b* are disengaged from the ratchet teeth **838** and the fastener **812** is able to be rotated out.

The fastening device technology described herein has unlimited application in industry and other uses. Particularly advantageous applications will involve use near motors or moving equipment in which vibration may cause loosening of traditional fasteners such as in automotive applications, aerospace applications, and manufacturing machinery. The present fastening device technology is also well suited for medical applications such as attaching pedicle screws to spinal rods, attaching spinal plates and fracture plates, fixing artificial joints like hips and knees, and the like.

While the subject invention has been described with respect to preferred and exemplary embodiments, those skilled in the art will readily appreciate that various changes and/or modifications can be made to the invention without departing from the spirit or scope of the invention as described herein and as defined by the appended claims.

What is claimed is:

1. A fastening device, comprising:

a locking structure having at least one locking tooth; and

a fastener having a head portion, an elongated threaded body portion extending axially from the head portion, and a rim portion intermediate the head portion and threaded body portion, the rim portion including a pair of pawl arms incorporated into the rim portion and extending from the head portion, each pawl arm including a fastener tooth disposed on a distal end thereof for ratcheted engagement with the at least one locking tooth of the locking structure.

2. A fastening device as recited in claim **1**, wherein the locking structure includes a plate structure having an axial recess and a plurality of radially extending locking teeth configured to engage the fastener tooth of each pawl arm.

3. A fastening device as recited in claim **2**, wherein the at least one locking tooth of the locking structure is disposed on the bottom of the axial recess.

4. A fastening device as recited in claim **2**, wherein the at least one locking tooth of the locking structure is disposed in a sidewall of the axial recess.

5. A fastening device as recited in claim **1**, wherein the locking structure includes a plate structure defining a recess complementing a shape of the head portion, the recess having a plurality of locking teeth arranged axially to interact with the fastener tooth during tightening of the fastener.

6. A fastening device as recited in claim 1, wherein a second fastener tooth is disposed on the distal end of the pawl arm adjacent to the first fastener tooth.

7. A fastening device as recited in claim 1, wherein the rim portion defines slots that partially define the pawl arms.

8. A fastening device as recited in claim 1, wherein the pawl arms define axial slots that are adjacent to the fastener teeth.

9. A fastening device as recited in claim 1, wherein the head portion defines an axial aperture extending at least into the rim portion.

10. A fastening device as recited in claim 9, wherein the axial aperture is a first axial aperture, and further including a second axial aperture extending at least into the rim portion, wherein the first and second axial apertures are configured to receive projections disposed on a distal working portion of a driving tool.

11. A fastening device as recited in claim 1, wherein the head portion defines an axial aperture extending through the rim portion.

12. A fastening device as recited in claim 11, wherein the axial aperture is a first axial aperture, and further including a second axial aperture extending through the rim portion, wherein the first and second axial apertures are configured to receive projections disposed on a distal working portion of a driving tool.

13. A fastening kit, comprising:

a locking structure having at least one locking tooth;

a fastener having a head portion, an elongated threaded body portion extending axially from the head portion, and a rim portion intermediate the head portion and threaded body portion, the rim portion including a pair of pawl arms incorporated into the rim portion and extending from the head portion, each pawl arm including a fastener tooth disposed on a distal end of the pawl arm for ratchet engagement with the at least one locking tooth of the locking structure; and

a driving tool for tightening and removing the fastener from the locking structure, wherein the driving tool including two projections on a distal working portion of the driving tool.

14. A fastening kit as recited in claim 13, wherein the head portion defines an axial aperture extending at least into the rim portion.

15. A fastening kit as recited in claim 14, wherein the axial aperture is a first axial aperture, and further including a second axial aperture extending at least into the rim portion, wherein the first and second axial apertures are configured to receive projections disposed on the distal working portion of the driving tool.

16. A fastening kit as recited in claim 13, wherein the head portion defines an axial aperture extending through the rim portion.

17. A fastening kit as recited in claim 16, wherein the axial aperture is a first axial aperture, and further including a second axial aperture extending through the rim portion, wherein the first and second axial apertures are configured to receive projections disposed on the distal working portion of the driving tool.

18. A fastening kit as recited in claim 13, wherein the pawl arms define axial slots that are adjacent to the fastener teeth, wherein the projections of the distal working portion of the driving tool include tips configured to be received within respective axial slots defined in the pawl arms.

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